CIAOGCR   CD 75-01   UNCLASSIFIED-CARTOGRAPHIC AUTOMATIC MAPPING PROGRAM DOCUMENTATION-VERSION 4

CIA MAR75

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CAM

Cartographic Automatic Mapping Program Documentation-Version 4

~~For Reference~~

~~Not to be taken from this Room~~

OGCR CD 75-1 (Revision)
March 1975

CAM

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PREFACE

The Cartographic Automatic Mapping (CAM) Program is the output portion of AUTOMAP—an automatic mapping system developed by the Central Intelligence Agency that enables the user to convert digitized data into geographic coordinates and to automatically draw maps. Other parts of the system are the BUDAK program, which converts the X-Y data of six projections into latitude and longitude values, and World Data Bank I (WDB I), which is an approximately 100,000 point digital representation of World coastlines and international boundaries. Both are available from the National Technical Information Service.

CAM is an IBM Systems 360 Fortran program that performs a wide variety of cartographic plotting tasks. It will connect points with straight lines or great circles and draw line grids, range rings, ellipses, cones, azimuths, and a host of other map features. Included also are a selection of 17 map projections that can be used in conjunction with either an 8,200 point World shoreline found on the CAM tape or the WDB I, which is separate. The structure of CAM is modular to permit the easy addition of new features or subroutines to read data in a different format.

New features included in Version 4 of CAM are the Polyconic projection, UTM grids and ticks, longitude and latitude ticks, legend box blockout, a route and corridor option, and twelve new line symbols. The sample plot instructions have been combined with the projection descriptions, which have been rewritten to be understandable to the noncartographer. 25X1A

NOTE: This program was written and documented by [redacted] CIA Office of Joint Computer Support, and edited by [redacted] CIA Office of Geographic and Cartographic Research. Corrections and suggestions are welcome and should be directed to ATD/GCR, Central Intelligence Agency, Washington, D.C. 20505. 25X1A

Approved For Release 2000/09/14 : CIA-RDP86T00608R000600100004-2

Credit is gratefully given to Ronald M. Bolton now at the National Oceanic and Atmospheric Agency for his continuing aid with projection programming, to [redacted] for his editorial review, and to Dr. Alan Hershey of the U.S. Naval Research Laboratory at Dahlgren, Va. for the digital outline of the World. Countless others in government, industry and at universities have also contributed in many ways.

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I. USER'S GUIDE

A. Introduction

1. Job Outline

Step 1 Identify Plotter
Step 2 Identify Projection
Step 3 Other Identifiers
  Center Point
  Map Boundaries
  Map Scale
Step 4 Optional Data Words
Step 5 Plotter Board Size (XYLIM)
Step 6 Command Words

2. Description

The CAM uses a "Problem Oriented Language" (POL) type of data card structure, whereby the program performs only those functions specified by the user. The POL is divided into "DATA" words and "COMMAND" words. The COMMAND words are used to cause execution of the program with values given by the DATA words and current COMMAND word. Therefore, the only function of the DATA words is to input values to the program.

All of the program input parameters are initialized to zero except EATRAD (3437.9768) and CONFAC (72960.).

3. COMMAND Words

BODE	Draws azimuth lines and elevation rings from a given center point
BOX	Draws a rectangle around a given point at a given size (inches)
BRANGE	Draws a geographic area box around a given center point (nautical miles)
CIRCLE	Draws a circle around a given point at a given radius (inches)
CORRIDOR	Draws a corridor along a given path
ELIPSERG	Draws an ellipse around a given point
GTCIRCLE	Draws great circle paths
LALOTICK	Draws latitude/longitude ticks
LGRID	Draws latitude/longitude grid
LINEPT	Connects points with straight lines
METKGRID	Draws UTM ticks
RRANGE	Draws range ring(s) around a given point at given nautical mile radii
SOLIDFIL	Solid fills an area with lines or symbols or cross hatches an area
SYMPT	Prints or draws symbols at given locations
UTMGRID	Draws meter grid along UTM grid

4. DATA Words

AZED	Azimuthal Equidistant Projection
AZEQAREA	Azimuthal Equal-Area Projection
CALIB	Scale calibration
CEAGEN	Albers Projection
CEIKIV	Kavraiskiy IV Projection
CEIPOS	Ptolemy Projection
CENTERTK	Control parameter for center mark (plus sign)
CETPOT	Map center point
CONFAC	Conversion factor
CORNERTK	Control parameter for corner ticks
EATRAD	Earth Radius
ECCENT	Eccentricity of the earth
EOF	End of file
GNOMONIC	Gnomonic Projection
LAMBERT	Lambert Conformal Conic Projection
LINEMODE	Selects solid line, dashed line, rail ticks, reefs or canals
MAPBOUND	Map boundaries - Latitudes and Longitudes
MAPSAL	Map scale

MERCAT	Mercator Projection
MILCYL	Miller Cylindrical Projection
ONOPOT	XY Display
OPENBOX	Open box option
ORTHO	Orthographic Projection
PERSP	Perspective Projection
PLOTTER	Plotter card for line or symbol
POLYCON	Polyconic Projection
RECTAN	Equirectangular Projection
REGISTK	Control parameter for radial register ticks
REVRSXY	Reverses the X and Y axis
SAVE	Saves input data
SCRIBE	Used for scribing
SINEAR	Sinusoidal Projection
SPLATE	Identifies end of separation plate
STEREO	Stereographic Projection
TMERCT	Transverse Mercator Projection (Sphere)
TMERSD	Transverse Mercator Projection (Spheroid)
XYLIM	X-Distance and Y-Distance limits of map
XYOFF	X and Y offsets from origin

5. Special Considerations

a. All longitude values west of the zero meridian are negative and all latitude values south of the equator are negative.

b. All numeric data input to the program must have the decimal point properly placed, otherwise the program will assume the decimal point follows the last digit.

c. The CAM card is made up of the Identifier and a series of fields. The fields are separated by commas. When fields are not used they may be replaced by a comma or zero, comma.

Name01.,2.,,4.
Name = Identifier
0 = Blank
1., = Field one
2., = Field two
, = Field three not used in this example
4. = Field four

B. Identify Plotter

PLOTTER (Identifier) Plotter Commands
Field 1—Data Set Reference Number of plotter output tape
Field 2—Pen or aperture to be used
Field 3—Plot tolerance between consecutive points (minimum distance)
Field 4—Plotter control parameter
= 1, Parameters in calling sequence of each plot subroutine are printed
= 8, CALCOMP 1136
= 9, CALCOMP 1136 & Print
= 10, Gerber Plotter
= 11, Gerber Plotter & Print
= 12, Graphic Data Format
Field 5—Symbol control parameter
= 0, Draws the symbols with software at plotter
= 1, Draws the symbols with software in CAM
= 2, Flashes the symbol (Request the aperture or symbol number in Field 10 of this card)
= 3, Selects symbol from symbol table—Symbol number is given in Field 10 of this card)
Field 6—Height of symbol to be drawn in multiples of .01 inch
Field 7—Angle at which the symbols are drawn (degrees)
Field 8—Maximum distance between consecutive points
Field 9—Not used
Field 10—Symbol selection from symbol table

C. Identify Projection

AZED (Identifier) Azimuthal Equidistant Projection
Field 1 Maximum radius of projection (nautical miles)
AZEQAREA (Identifier) Azimuthal Equal-Area Projection
Field 1 Maximum radius of projection (nautical miles)
CEAGEN (Identifier) Albers Projection (CONFAC must be input as 39.37)
Field 1 Semi-major axis in meters (6378388.)
Field 2 Semi-minor axis in meters (6356912.)
Field 3 Not used
Field 4 Latitude of lower standard parallel, degree
Field 5 Latitude of lower standard parallel, minute
Field 6 Latitude of lower standard parallel, second
Field 7 Latitude of upper standard parallel, degree
Field 8 Latitude of upper standard parallel, minute
Field 9 Latitude of upper standard parallel, second
CEIKIV (Identifier) Kavraiskiy IV Projection
Field 1 Control parameter
= 0, Computes constants of the cone and integration from the standard parallels
= 1, Uses input values
Field 2 Constant of the cone
Field 3 Constant of integration
Field 4 Latitude of lower standard parallel, degree
Field 5 Latitude of lower standard parallel, minute
Field 6 Latitude of lower standard parallel, second
Field 7 Latitude of upper standard parallel, degree
Field 8 Latitude of upper standard parallel, minute
Field 9 Latitude of upper standard parallel, second
CEIPOS (Identifier) Ptolemy Conic Equal-Interval Projection
Field 1 Control parameter
= 0, Computes constants of the cone and integration from the standard parallels
= 1, Uses input values
Field 2 Constant of the cone
Field 3 Constant of integration
Field 4 Latitude of the standard parallel, degree
Field 5 Latitude of the standard parallel, minute
Field 6 Latitude of the standard parallel, second
GNOMONIC (Identifier) Gnomonic Projection
LAMBERT (Identifier) Lambert Conformal Conic Projection
Field 1 Control parameter for computing constants for the cone, integration from the standard parallels and determining position of cone
= −2, Use input values for constants, cone over South Pole
= −1, Compute constants, cone over South Pole
= 0, and 1, Compute constants, cone over North Pole
= 2, Use input values for constants, cone over North Pole
Field 2 Constant of the cone
Field 3 Constant of integration
Field 4 Latitude of lower standard parallel, degree
Field 5 Latitude of lower standard parallel, minute
Field 6 Latitude of lower standard parallel, second
Field 7 Latitude of upper standard parallel, degree
Field 8 Latitude of upper standard parallel, minute
Field 9 Latitude of upper standard parallel, second

Field 10 Control parameter when cone is over South Pole
0, Puts North at top of map
1, Puts South at top of map
MERCAT (Identifier) Mercator Projection
Field 1 True scale latitude, degree part
Field 2 True scale latitude, minute part
Field 3 True scale latitude, second part
MILCYL (Identifier) Miller Cylindrical Projection
Field 1 True scale latitude, degree part
Field 2 True scale latitude, minute part
Field 3 True scale latitude, second part
ONOPOT (Identifier) XY Display used for plotting digitized data
Field 1 Number of digitized counts per inch
Field 2 Sets of data points per record
Normal setup for the Bendix digitized data is 1.,1.
MAPSAL may be used to change size of data
Example MAPSAL 1. Plots data one for one
MAPSAL 2. Plots data double digitized size
MAPSAL .5 Plots data half the digitized size
ORTHO (Identifier) Orthographic Projection
PERSP (Identifier) Perspective Projection
Field 1 Altitude in nautical miles
POLYCON (Identifier) Polyconic Projection
Field 1 Semi-major axis of spheroid in meters
Field 2 Semi-minor axis of spheroid in meters
Field 3 Central meridian, degree part
Field 4 Central meridian, minute part
Field 5 Central meridian, second part
RECTAN (Identifier) Equirectangular Projection
Field 1 Distance from the center point to the right boundary (inches)
Field 2 Distance from the center point to the upper boundary (inches)
SINEAR (Identifier) Sinusoidal Projection
STEREO (Identifier) Stereographic Projection
Field 1 True scale latitude, degree part
Field 2 True scale latitude, minute part
Field 3 True scale latitude, second part
Field 4 Maximum radius in nautical miles
TMERCT (Identifier) Transverse Mercator Projection centered on 0N, 0E
Field 1 True scale latitude, degree part
Field 2 True scale latitude, minute part
Field 3 True scale latitude, second part
TMERSD (Identifier) Transverse Mercator Spheroid Projection
Field 1 Semi-major axis of spheroid in meters
Field 2 Semi-minor axis of spheroid in meters
Field 3 Central meridian, degree part
Field 4 Central meridian, minute part
Field 5 Central meridian, second part

D. Other Identifiers

CETPOT (Identifier) Center point of map. It is not necessary that this point fall within the area being plotted.
Field 1—Latitude, degree part
Field 2—Latitude, minute part

Field 3 Latitude, second part
Field 4 Longitude, degree part
Field 5 Longitude, minute part
Field 6 Longitude, second part

EOF (Identifier) End of file is put on plot tape

MAPBOUND (Identifier) Outline boundaries for map computation
Field 1 Latitude of lower boundary, degree part
Field 2 Latitude of lower boundary, minute part
Field 3 Latitude of lower boundary, second part
Field 4 Latitude of upper boundary, degree part
Field 5 Latitude of upper boundary, minute part
Field 6 Latitude of upper boundary, second part
Field 7 Longitude of left boundary, degree part
Field 8 Longitude of left boundary, minute part
Field 9 Longitude of left boundary, second part
Field 10 Longitude of right boundary, degree part
Field 11 Longitude of right boundary, minute part
Field 12 Longitude of right boundary, second part

MAPSAL (Identifier) Map scale
Field 1 Map scale (Denominator of Representative Fraction). Radius of plot in inches for Azimuthal, Orthographic, Stereographic and Perspective Projections.

SAVE (Identifier) Saves all values from "DATA" cards

SPLATE (Identifier) Causes an End of File to be put on plot tape along with corner ticks, center ticks, and/or registry lines

XYLIM (Identifier) X-Distance and Y-Distance limits of plotter
Field 1 Distance from center of plotter board to right hand margin (inches)
Field 2 Distance from center of plotter board to top margin (inches)

E. Optional Data Words

1 (Identifier) Plot title
In positions 5–44 the title of the plot. This is plotted at some X,Y position as specified in the next data card (2F10.0). X,Y values are in inches referenced from center. The SAVE data card must precede the first "1" card.

2 (Identifier) Message to Plotter Operator
In positions 5–64, the message for the plotter operator. The SAVE data card must precede the first "2" card.

CALIB (Identifier) Map scale calibration parameters
Field 1 Y Distance from map center to point A (inches)
Field 2 X Distance from map center to point A (inches)
Field 3 Y Distance from map center to point B (inches)
Field 4 X Distance from map center to point B (inches)
Field 5 Latitude of Point A, degree part
Field 6 Latitude of Point A, minute part
Field 7 Latitude of Point A, second part
Field 8 Longitude of Point A, degree part
Field 9 Longitude of Point A, minute part
Field 10 Longitude of Point A, second part
Field 11 Latitude of Point B, degree part
Field 12 Latitude of Point B, minute part
Field 13 Latitude of Point B, second part
Field 14 Longitude of Point B, degree part
Field 15 Longitude of Point B, minute part
Field 16 Longitude of Point B, second part

CALIB is used to calibrate the map scale of a map sheet you are printing on or over.

For example, this will adjust the scale to fit a paper copy which has the scale rounded off or where the paper has expanded or has shrunk. Also useful when the scale is unknown.

CENTERTK (Identifier) Control parameter for center tick

*CONFAC (Identifier) Conversion factor

Field 1 Number of inches in nautical mile

CORNERTK (Identifier) Control parameter for corner ticks

*EATRAD (Identifier) Earth radius

Field 1 Earth radius

ECCENT (Identifier) Eccentricity of Earth

Field 1 Value used .0822718

LINEMODE (Identifier) For selection of solid or dashed lines, railroad, canal or reef symbols. Note that each Field 1 defines the symbol and Fields 2-7 depend on that selection.

Field 1 0 Solid line

Field 1 1 Dashed line
- Field 2 Length of dash - inches
- Field 3 Length of space - inches

Field 1 2 Irregular Dashed line (long-short-long)
- Field 2 Length of dash - inches
- Field 3 Length of space - inches
- Field 4 Length of smaller dash - inches

Field 1 3 Irregular Dashed line (long-short-short-long)
- Field 2 Length of dash - inches
- Field 3 Length of space - inches
- Field 4 Length of smaller dash - inches

Field 1 4 Standard and Broad Gauge Railroad Symbol
- Field 2 Distance between ticks - inches
- Field 3 Length of whole tick - inches
- Field 4 Pen or aperture for tick
- Field 5 Data Set Reference Number of the temporary work space**

Field 1 5 Narrow Gauge Railroad Symbol (alternating ticks)
- Field 2 Distance between ticks - inches
- Field 3 Length of tick on one side of line - inches
- Field 4 Pen or Aperture for tick
- Field 5 Data Set Reference Number of the temporary work space**

Field 1 6 Broad Gauge Railroad Under Construction Symbol
- Field 2 Length of dash - inches
- Field 3 Length of space - inches
- Field 4 Pen or Aperture for the tick
- Field 5 Length of whole tick - inches
- Field 6 Data Set Reference Number of the temporary work space**
- Field 7 Distance between ticks in inches which should equal Field 2 plus Field 3. This is optional and is calculated within program.

Field 1 7 Narrow Gauge Railroad Under Construction Symbol
- Field 2 Length of dash - inches
- Field 3 Length of space - inches
- Field 4 Pen or Aperture for the tick
- Field 5 Length of Tick on one side of line - inches
- Field 6 Data Set Reference Number of the temporary work space**
- Field 7 Distance between ticks in inches which should equal Field 2 plus Field 3. This is optional and is calculated within program.

*Note: CONFAC and EATRAD have values (72960 and 3437.9768) already in the program and need values only in special cases when different values are needed for an unusual projection or area. All other parameters are initialized to zero.

Field 1 — 8 Reef Symbol (sawtoothed line)
Field 2 Amplitude desired inches. Give half value, e.g., 0.1 0.2 amplitude, .5 1.0 etc.
Field 1 — 9 Multiple-Track Railroad Symbol (double ticks)
Field 2 Distance between double-tick sets inches
Field 3 Length of whole tick inches
Field 4 Pen or Aperture for tick
Field 5 Distance between ticks within double-tick sets inches
Field 6 Data Set Reference Number of the temporary work space**
Field 1 — 10 Multiple-Track Railroad Under Construction Symbol
Field 2 Length of dash inches
Field 3 Length of space inches
Field 4 Pen or Aperture for the tick
Field 5 Length of whole tick inches
Field 6 Data Set Reference Number of the temporary work space**
Field 7 Distance between ticks within double-tick sets inches. Distance between double-tick sets is calculated in program and should equal Field 2 + Field 3 Field 7.
Field 1 — 11 Canal Symbol
Field 2 Distance between ticks inches
Field 3 Length of tick on one side of line inches
Field 4 Pen or Aperture for ticks
Field 5 Data Set Reference Number for temporary work space**
Field 1 — 12 Irregular Dashed Line (long-short-short-short-long)
Field 2 Length of dash inches
Field 3 Length of space inches
Field 4 Length of smaller dash inches

**Note: The DD cards for temporary work space are:

```
//FT F001 DD UNIT  SYSDA,DISP  (NEW,DELETE),
//              DSN  &&RRTICK,SPACE  (TRK,(10,5)),
//              DCB  (RECFM  VB,LRECL  804,BLKSIZE  3220)
```

OPENBOX (Identifier) Open Box Option. Deletes map data within specified frame.
Field 1 Control Parameter
0, open box not desired
1, open box desired

Note: Down and left from map center are negative values
Field 2 Distance from map center to left side of open box inches
Field 3 Distance from map center to bottom side of open box inches
Field 4 Distance from map center to right side of open box inches
Field 5 Distance from map center to top of open box inches
Field 6 Control Parameter
=0, or blank if no border around open box is desired
=1, if border around open box is desired

REGISTK (Identifier) Register ticks
Field 1 Distance from frame to start drawing register ticks inches
Field 2 — Length of register ticks inches

REVRSXY (Identifer) To reverse the X and Y axis

SCRIBE (Identifier) Used for scribing
Field 1 Control Parameter
=0, Positive image is generated
=1, Negative image

XYOFF (Identifier) To offset the origin
Field 1 — X Offset; Plus moves origin to the right, Minus to the left
Field 2 — Y Offset; Plus moves origin up, Minus moves it down

F. COMMAND Words

BODE (Identifier) Azimuth lines and elevation rings
- Field 1 Latitude of center point, degree part
- Field 2 Latitude of center point, minute part
- Field 3 Latitude of center point, second part
- Field 4 Longitude of center point, degree part
- Field 5 Longitude of center point, minute part
- Field 6 Longitude of center point, second part
- Field 7 Nautical mile distance from center point to start azimuth lines
- Field 8 Nautical mile distance from center point to end of azimuth lines
- Field 9 Nautical mile increment used for generating azimuth lines
- Field 10 Azimuth interval in degrees. If less than or equal to zero, no azimuth lines will be drawn.
- Field 11 Altitude of vehicle for elevation rings nautical miles
- Field 12 Height of center point above sea level feet
- Field 13 Elevation angle to start elevation rings degrees
- Field 14 Elevation angle to terminate elevation rings degrees
- Field 15 Elevation angle increment for elevation rings degrees. If less than or equal to zero, no elevation rings will be drawn.
- Field 16 Angular increment used to generate rings degrees
- Field 17 Tick marks placed every field 17 nautical miles on given azimuth lines. If less than or equal to zero, no ticks will be drawn.
- Field 18 Azimuths for tick marks degrees
- Field 19 Angle from north to start drawing azimuth lines and elevation rings degrees
- Field 20 Angle from north to terminate drawing azimuth lines and elevation rings degrees

BOX (Identifier) To draw rectangle neatline and or border
- Field 1 Latitude of center point, degree part
- Field 2 Latitude of center point, minute part
- Field 3 Latitude of center point, second part
- Field 4 Longitude of center point, degree part
- Field 5 Longitude of center point, minute part
- Field 6 Longitude of center point, second part
- Field 7 Distance from center to right margin inches
- Field 8 Distance from center to top margin inches

BRANGE (Identifier) To draw geographic box
- Field 1 Latitude of center point, degree part
- Field 2 Latitude of center point, minute part
- Field 3 Latitude of center point, second part
- Field 4 Longitude of center point, degree part
- Field 5 Longitude of center point, minute part
- Field 6 Longitude of center point, second part
- Field 7 Distance from center to right edge nautical miles
- Field 8 Distance from center to top nautical miles
- Field 9 Increment to generate lines nautical miles

CIRCLE (Identifier) To draw a circle
- Field 1 Latitude of center point (circle), degree part
- Field 2 Latitude of center point (circle), minute part
- Field 3 Latitude of center point (circle), second part
- Field 4 Longitude of center point (circle), degree part
- Field 5 Longitude of center point (circle), minute part
- Field 6 Longitude of center point (circle), second part
- Field 7 Radius of circle inches

Field 8 Degree increment used in stepping azimuth for the circle
Field 9 Control for tick marks
 < or 0, no tick marks
 > 0, tick marks are drawn every field 9 degrees
Field 10 Length of ticks (inches)

CORRIDOR (Identifier) To draw a corridor
Field 1 Data Set Reference Number for corridor data
Field 2 Type of format for corridor data
Field 3 Data Set Reference Number for temporary work space*
Field 4 Angular increment used to step around curves
Field 5 Width of corridor (nautical miles)
Field 6 Control parameter for side
 0, corridor drawn on both sides
 1, drawn on +90 side only
 2, drawn on −90 side only
Field 7 Increment used to step along corridor
Field 8 Rank Classification**
 0, All ranks
 > 0, Only specified ranks
Field 9 Beginning line identifier**
 0, All lines
 < 0, All lines except this one
 > 0, Beginning line identifier of a range, or if field 10 is blank, only this individual line
Field 10 Ending line identifer**
 0, See field 9
 > 0, Upper boundary of the line identifier range

*Note: DD cards for temporary work space for corridor:

```
FT F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),
           DSN=&&CORRID,SPACE=(TRK,(10,5)),
           DCB=(RECFM=VB,LRECL=804,BLKSIZE=3220)
```

**Note: Fields 8, 9, and 10 apply only to Graphic Data, World Data Binary and the Direct Access Data Base Formats.

ELIPSERG (Identifier) Ellipse
Field 1 Latitude of center point, degree part
Field 2 Latitude of center point, minute part
Field 3 Latitude of center point, second part
Field 4 Longitude of center point, degree part
Field 5 Longitude of center point, minute part
Field 6 Longitude of center point, second part
Field 7 Semi-major axis (nautical miles)
Field 8 Semi-minor axis (nautical miles)
Field 9 Orientation of ellipse from north (degrees)
Field 10 Angle from north to start drawing ellipse (degrees)
Field 11 Angle from north to end drawing ellipse (degrees)
Field 12 Angular increment used to generate ellipse (degrees)
Field 13 Control parameter for ellipse centers
 = < or 0, will use fields 1–6 as center
 = > 0, data set reference number where centers are located

GTCIRCLE (Identifier) Great circle paths
Field 1 Nautical mile increment used for generating points in the great circle path between the input values
Field 2 Data set reference number where input values of great circle paths are located (must be in World Data Bank 80 character format for degrees, minutes, seconds two consecutive cards with 9 in column one indicate end of data)

Approved For Release 2000/09/14 : CIA-RDP86T00608R000600100004-2

LALOTICK (Identifier) Latitude/Longitude ticks
Field 1 Longitude interval between ticks—degrees
Field 2 Latitude interval between ticks—degrees
Field 3 Length of tick in longitude direction—seconds. If this value is less than or equal to zero, the parallel (East-West) part of tick will not be drawn.
Field 4 Length of tick in latitude direction—seconds. If this value is less than or equal to zero, the meridian (North-South) part of the tick will not be drawn.
Field 5 Latitude of lower boundary, degree part
Field 6 Latitude of lower boundary, minute part
Field 7 Latitude of lower boundary, second part
Field 8 Latitude of upper boundary, degree part
Field 9 Latitude of upper boundary, minute part
Field 10 Latitude of upper boundary, second part
Field 11 Longitude of left boundary, degree part
Field 12 Longitude of left boundary, minute part
Field 13 Longitude of left boundary, second part
Field 14 Longitude of right boundary, degree part
Field 15 Longitude of right boundary, minute part
Field 16 Longitude of right boundary, second part

LGRID (Identifier) Line grid
Field 1 Interval between meridians on grid—degrees. If this value is less than or equal to zero, meridians will not be drawn.
Field 2 Interval between parallels on grid—degrees. If this value is less than or equal to zero, parallels will not be drawn.
Field 3 Degree increment used for generating points to define parallels
Field 4 Degree increment used for generating points to define meridians
Field 5 Latitude of lower boundary, degree part (Begin with multiple of field 1)
Field 6 Latitude of lower boundary, minute part
Field 7 Latitude of lower boundary, second part
Field 8 Latitude of upper boundary, degree part
Field 9 Latitude of upper boundary, minute part
Field 10 Latitude of upper boundary, second part
Field 11 Longitude of left boundary, degree part (Begin with multiple of field 2)
Field 12 Longitude of left boundary, minute part
Field 13 Longitude of left boundary, second part
Field 14 Longitude of right boundary, degree part
Field 15 Longitude of right boundary, minute part
Field 16 Longitude of right boundary, second part

LINEPT (Identifier) Line plot to draw coastlines, boundaries or any other lines
Field 1 Data Set Reference Number for data to be line plotted. User must supply necessary DD cards to describe his data.
Field 2 Specified format of user data
=1, World Data Bank Format—80 character logical records, unblocked or blocked, picks up latitude and longitude in radians
=2, World Data 22 Byte Binary Format
=3, Graphic Data Format
=4, Not used
=5, World Data Bank Format—picks up degrees, minutes and seconds
=6, Dahlgren Format
=7, Trace I Format
=8, Not used
=9, Data Base—direct access

Field 3 Rank Classification
- 0, All lines
- 0, Only specified rank

Field 4 Beginning line identifier
- 0, All lines
- 0, All lines except this one
- 0, Individual line, if field 5 is blank or beginning line identifier of series to be plotted

Field 5 Ending line identifier
- 0, See Field 4
- 0, Upper boundary of line identifier of series to be plotted

Note: Fields 3, 4 and 5 apply only to Graphic Data, World Data Binary and the Direct Access Data Base Formats

METKGRID (Identifier) Ticks along UTM grid

Field 1 Interval between meridians on the grid meters
Field 2 Interval between parallels on the grid meters
Field 3 Length of tick along parallels meters. If this value is less than or equal to zero, the parallel (East-West) part of the tick will not be drawn.
Field 4 Length of tick along meridians meters. If this value is less than or equal to zero, the meridian (North-South) part of the tick will not be drawn.
Field 5 Latitude of lower boundary, degree part
Field 6 Latitude of lower boundary, minute part
Field 7 Latitude of lower boundary, second part
Field 8 Latitude of upper boundary, degree part
Field 9 Latitude of upper boundary, minute part
Field 10 Latitude of upper boundary, second part
Field 11 Longitude of left boundary, degree part. Must not be more than 3 degrees from central meridian.
Field 12 Longitude of left boundary, minute part
Field 13 Longitude of left boundary, second part
Field 14 Longitude of right boundary, degree part. Must not be more than 3 degrees from central meridian.
Field 15 Longitude of right boundary, minute part
Field 16 Longitude of right boundary, second part
Field 17 Zone designation for determining the central meridian of the zones
Field 18 Spheroid
- 1, International
- 2, Bessel
- 3, Everest
- 4, Clarke 1866
- 5, Clarke 1880

RRANGE (Identifier) Range rings – to draw range rings around any point

Field 1 Latitude of range ring center point, degree part
Field 2 Latitude of range ring center point, minute part
Field 3 Latitude of range ring center point, second part
Field 4 Longitude of range ring center point, degree part
Field 5 Longitude of range ring center point, minute part
Field 6 Longitude of range ring center point, second part
Field 7 Angle from north to start drawing range rings degrees
Field 8 Angle from north to terminate drawing range rings degrees
Field 9 Angular increment used to generate range rings degrees
Field 10 Range at which the first range ring is drawn nautical miles
Field 11 Range at which the last range ring is drawn nautical miles
Field 12 Range rings are drawn every Field 12 nautical miles

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Field 13 Control parameter for tick marks
  < 0 or 0, no tick marks
  > 0, tick marks are drawn every (Field 13) degrees
Field 14 Length of the tick marks - inches
Field 15 Control parameter for range ring centers
  < or 0, will use Fields 4-6 as center
  > 0, the data set reference number where the centers are in MBFMT format

SOLIDFIL (Identifier) Fills an area with lines or symbols or cross hatches an area. Outer boundaries are indicated by the tens position of the line identifier and inner areas by the units position. Outer boundary must be counterclockwise and inner areas must be clockwise. Maximum number of points in all lines is 3000.

Field 1 Data set reference number for input data
Field 2 Format description - All formats listed under Field 2 of LINEPT are valid
Field 3 Distance between lines - For solid fill this is equal to aperture width which is selected by the plotter card
Field 4 The fill option
  1, Solid fill or line fill
  2, Symbol fill - Area is filled with the symbol and at the height as specified on the plotter card. Default symbol is "A" and default height .75 times Field 3.
  3, Cross hatches
Field 5 The angle for line, or symbol or cross hatching
  Positive Angle - Up from X axis
  Negative Angle - Down from X axis
Field 6 Rank Classification
  0, All ranks
  > 0, Only specified ranks
Field 7 Beginning line identifier
  0, All lines
  > 0, Beginning line identifier
Field 8 Ending line identifier

SYMPT (Identifier) Symbol plotting - to plot symbols from card or tape

Field 1 Format description
  1, Trace I Format - puts the symbol "." at each point
  2, MBFMT Format, if number of symbols is equal to -1, then the first 3 positions of the symbol field identify the symbol aperture or the location in the symbol table
  3, World Data Bank Format - 80 character logical records, unblocked or blocked - picks up latitude and longitude in radians
  4, World Data 22 Byte Binary Format
  5, Graphic Data Format
  6, Not used
  7, World Data Bank Format - picks up degrees, minutes and seconds
  8, Dahlgren Format
  9, Trace I Format
  10, Not used
  11, Data Base - direct access
Field 2 Data Set Reference Number for input data. User must supply DD cards to describe his data.
Field 3 Rank Classification
  0, All lines
  > 0, Only specified rank

Field 4 Beginning line identifier
- 0, All lines
- 0, All lines except this one
- >0, Individual line, if Field 5 is blank or beginning line identifier of range

Field 5 Ending line identifier
- 0, See Field 4
- , Upper boundary of line identifier range

Note: Fields 3, 4 and 5 apply only to Graphic Data, World Data Binary and Direct Access Data Base Formats.

UTMGRID (Identifier) UTM grid

Field 1 Interval between meridians on the grid meters. If this value is less than or equal to zero, meridians will not be drawn.
Field 2 Interval between parallels on the grid meters. If this value is less than or equal to zero, parallels will not be drawn.
Field 3 Meter increment for generating points to define parallels
Field 4 Meter increment for generating points to define meridians
Field 5 Latitude of lower boundary, degree part
Field 6 Latitude of lower boundary, minute part
Field 7 Latitude of lower boundary, second part
Field 8 Latitude of upper boundary, degree part
Field 9 Latitude of upper boundary, minute part
Field 10 Latitude of upper boundary, second part
Field 11 Longitude of left boundary, degree part. Must not be more than 3 degrees from central meridian.
Field 12 Longitude of left boundary, minute part
Field 13 Longitude of left boundary, second part
Field 14 Longitude of right boundary, degree part. Must not be more than 3 degrees from central meridian.
Field 15 Longitude of right boundary, minute part
Field 16 Longitude of right boundary, second part
Field 17 Zone designation for determining the central meridian of the zones
Field 18 Spheroid
- 1, International
- 2, Bessel
- 3, Everest
- 4, Clarke, 1866
- 5, Clarke, 1880

G. Sample Program (see Figure 1)

1. Identify plotter	PLOTTER 14.,3.,.01,10.,1.,7.,.2.
2. Identify projection	AZED 6000.
3. Define:	
Center Point	CETPOT 42.,30.,,18.,45.
Map Boundaries	MAPBOUND 90.,,,90.,,, 180.,,,180.
Map Scale	MAPSAL 2.5
4. Optional data words to be used with all files	
Corner Ticks	CORNERTK
Register Ticks	REGISTK .5,.25
5. Plotting film size	XYLIM 5.5,7.
Film size is 11 by 14	
Saves input data	SAVE
Actual plot window	XYLIM 2.75,2.75

To save plot window	SAVE	
Messages to plotter		
Operator to come out on teletype	2	PLOT SIZE IS 11 BY 14
	2	PLOT ON CLEAR FILM
File mark to stop plotter but does not call for register ticks also stop for operator to read instructions	EOF	
Information to be drawn on separation plate	1	SAMPLE TITLE
X, Y location to be placed	-2.75	-2.95
Optional data word to be used with circle only	CENTERTK	
Circle command word	CIRCLE 42.,30.,,18.,45.,,2.5,1.	
Optional data word for following command word only. Grid will stop at 90N and 90S		
Line grid	LGRID 30.,30.,1.,1., −90.,,,90.,,, −180.,,,180.	
To put end of file and register marks on tape for first separation plate	SPLATE	
Coastline	LINEPT 8.,2.	
Boundary	LINEPT 11.,2.	
Second separation plate	SPLATE	
Symbol printing		
Symbol command word	SYMPT 2.,7.	
Data to be plotted, data must be followed by two cards with 9's in columns 60 and 61	1 +	423000N0184500E
		99
		99
Third separation plate	SPLATE	
Draw range rings	RRANGE 42.,30.,,18.,45.,,,360,1,6000.,7500.,6000.	
Fourth separation plate	SPLATE	

H. Program Abnormal Terminations

101 Name exceeds 8 characters
102 Variable value exceeds 12 characters
150 Invalid character in input stream

I. Plotter DD Cards

CALCOMP THIRTY-SIX INCH PLOTTER (1136)

```
//FT14F001 DD DISP=(NEW,KEEP),LABEL=(1,BLP),
//    UNIT=(2400,,DEFER),
//    VOLUME=SER=CALP36,
//    DCB=(RECFM=VS,LRECL=484,BLKSIZE=488,DEN=2)
```

GERBER 1232

```
//FT14F001 DD DISP=(NEW,KEEP), LABEL=(1,BLP),
//    UNIT=(2400,,DEFER),
//    VOLUME=SER=GERBER,
//    DCB=(RECFM=F,BLKSIZE=1022,DEN=2)
```

GRAPHIC DATA FORMAT

```
//FT14F001 DD DISP=(NEW,KEEP), LABEL=(1,BLP),
//    UNIT=(2400,,DEFER),
//    VOLUME=SER=GDSET,
//    DCB=(RECFM=FB,LRECL=12,BLKSIZE=1200)
```

Figure 1. Sample Program Output

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II. PROGRAM SET-UP AND OPERATION

A. General

Once the CAM program has been compiled and link edited, it is advisable to put the load module on a disk. With the load module on disk, only the DD cards for the GO step are necessary for a computer run. The user should refer to the following two IBM manuals for a detailed explanation of DD cards.

FORTRAN IV (H) Programmer's Guide,
C28-6602
Job Control Language, C28-6539

DD cards are required for the plotter output and for all user input.

Please refer to the User's Guide for the DD cards for the various plotters.

B. Linkage Editor Overlay Cards

```
OVERLAY LINK1
  INSERT INPUTS,POLINP,CARDIN
  INSERT ADATA,ALFIE
OVERLAY LINK1
  INSERT OVRLAY,GRDLIN,CIRCLE,BODE,RARING,BOX,ELRING
  INSERT GRTCIR,RANBOX,LLTKGD,UTMGRD,GUMSCL,GUTMLL
  INSERT SOLARE,SOLFIL,CKWISE,INOUT,CALC,LOOK,MTKGRD
OVERLAY LINK1
  INSERT PITPOT,TGTSYM,GRASYM,TGTRED,TRACSY
OVERLAY LINK1
  INSERT CSCALE,CONINT,CONSAL,MERCAL,ONOSAL,AZSCAL,ORTSAL
  INSERT PERSAL,TMSCAL,LAMINT, RECSAL,POSCAL
  INSERT AZESAL,POLSAL
OVERLAY LINK1
  INSERT LINPOT
ENTRY MAIN
```

C. Deck Set-up to Execute Load Module

```
//                 Standard Job card
//                 EXEC PGM=CAM, REGION=250K, TIME=4
//STEPLIB          DD DSN=OBGLCART.LOAD, DISP=SHR
//SYSABEND         DD SYSOUT=A
//FT06F001         DD SYSOUT=A
/*                 DD Cards for the plotter output
/*                 DD Cards for the user input
//FT07F001         DD *
                   Data Cards Go Here
/*
```

D. World Data Bank I

It is recommended that the World Data Bank I (80 character format) be converted to the 22 byte binary format described on page 19 of the CAM documentation. This will save both input processing and CPU time. A listing of a Fortran program for the conversion and the suggested DCB parameters are as follows:

```
        EXEC FORTHCLG
     FORT.SYSIN DD *
C
C       PROGRAM TO REFORMAT WORLD DATA BANK 80 CHAR
C         RECORD TO 22 BYTE RECORD
C
        DATA NT,ND 10,8
        INTEGER*2 IRANK
C
        NP   0
C
        REWIND NT
10      READ (NT,100,END  300)LSEQ,RLAT,RLONG,IRANK,IREC
100     FORMAT(I7,2E20.8,21X,I2,I10)
        IF(LSEQ .EQ. 900000)GO TO 300
        WRITE (ND)LSEQ,IRANK,RLAT,RLONG,IREC
        NP   NP+1
        GO TO 10
300     REWIND NT
C
        WRITE (ND)LSEQ,IRANK,RLAT,RLONG,IREC
        WRITE (ND)LSEQ,IRANK,RLAT,RLONG,IREC
        END FILE ND
        REWIND ND
        WRITE (6,601)ND
601     FORMAT(2X,'NUMBER OF POINTS IN NEW FILE  ',I6  )
        STOP
        END
*
   GO.FT10F001 DD UNIT  (2400,,DEFER),DISP  (OLD,KEEP),
        LABEL  (,BLP),VOLUME  SER  TAPIN,
        DCB  (LRECL  80,BLKSIZE  3200,RECFM  FB)
   GO.FT08F001 DD UNIT  (2400,,DEFER),DISP  (NEW,KEEP),
        LABLE  (,BLP),VOLUME  SER  TAPOUT,
        DCB  (LRECL  22,BLKSIZE  3502,RECFM  VB)
*
```

III. INPUT/OUTPUT FORMAT SPECIFICATIONS

Only five of the most frequently used formats were selected for this report. There are many others, but they are too special-purpose for inclusion in this report.

A. Format MBFMT—for data to be symbol plotted

Fld. No.	Field Name	Format	Description of Data	Col. Pos.	Fld. Len.
1	*COUNT	I2	Number of characters in BLK1 to be plotted (0-40)	1-2	2
2	BLK1	14A4,A1	Alphanumeric Data	3-59	57
3	**LATD	I2	Latitude—degree part	60-61	2
4	LATM	I2	Latitude—minute part	62-63	2
5	LATS	I2	Latitude—seconds part	64-65	2
6	ALAT	A1	S for South, or N for North	66	1
7	LONGD	I3	Longitude—degree part	67-69	3
8	LONGM	I2	Longitude—minute part	70-71	2
9	LONGS	I2	Longitude—seconds part	72-73	2
10	ALONG	A1	E for East, or W for West	74	1
11	BLK2	6X	Blank	75-80	6

*A minus one (−1) in this field indicates that a three digit number is located in columns 3, 4, and 5. This three digit number is the location of a symbol in the symbol table.

**A 99 in the degree part indicates that an EOF will be put on the Plot tape. Two consecutive 99s in this field indicate no more data in this data set.

B. World Data Bank Format No. 1—record size is 80 characters

Fld. No.	Field Name	Format	Description of Data	Col. Pos.	Fld. Len.
1	*LSNUM	I7	Line Identifier	1-7	7
2	LATR	E20.8	Latitude in Radians ($-\pi/2 \rightarrow +\pi/2$)	8-27	20
3	LONGR	E20.8	Longitude in Radians ($-\Pi \rightarrow +\Pi$)	28-47	20
4	BLK1	3X	Blank	48-50	3
5	LATD	I2	Latitude—Degree part	51,52	2
6	LATM	I2	Latitude—Minute part	53,54	2
7	LATS	I2	Latitude—Seconds part	55,56	2
8	ALAT	A1	N for North, or S for South	57	1
9	LONGD	I3	Longitude—Degree part	58,59,60	3
10	LONGM	I2	Longitude—Minute part	61,62	2
11	LONGS	I2	Longitude—Seconds part	63,64	2
12	ALONG	A1	E for East, or W for West	65	1
13	BLK2	6X	Blank	66-71	6
14	SNUM	I9	Record Sequence Number	72-80	9

*A nine (9) in the first position indicates that an EOF will be put on plot tape. Two consecutive 9s indicate no more data in this data set.

C. Twenty-Two Byte Binary Format

Field	Description	Length
1	IBM/360 control word	4 bytes
2	Line identifier	4 bytes
3	Rank or class	2 bytes
4	Latitude in radians	4 bytes
5	Longitude in radians	4 bytes
6	Sequence count	4 bytes

D. Graphic Data File Format

1. Basic Commands

L	Move to a position Pen Up Line Segment info
b	Blank X, Y record. Move to position Pen down
S	Move to Position Pen Up and plot symbols
E	End of Data set
B	Beginning of Data set
C	Contour elevation value
P	Separation plate
M	Message to the Plotter teletype
F	Move to Position Pen Up & flash symbol

2. First Record in Data Set

	Position	Length	Format
B	1	1	A1
X length in .001″	2 6	5	I5
Y length in .001″	7 12	6	I6

3. Line Mode

	Position	Length	Format
First Record			
L	1	1	A1
Line Number	2 8	7	I7
Pen	9 10	2	I2
Rank/Classification	11 12	2	I2
Optional Record			
C	1	1	A1
Blanks	2 6	5	5X
Contour Elevation	7 12	6	I6
All Other Records			
X-integer in .001″	1 6	6	I6
Y-integer in .001″	7 12	6	I6

4. Symbol Mode

	Position	Length	Format
First Record			
S	1	1	A1
Symbol Number	2–7	6	I6

	Position	Length	Format
Pen	8 9	1	I2
Line Weight	10 12	1	I3
Second Record			
X size of character in .001"	1 4	4	I4
Y size of character in .001"	5 8	4	I4
Angle to be drawn degrees	9 12	4	I4
Third Record			
X center of first character	1 6	6	I6
Y center of first character	7 12	6	I6
Fourth Record			
Number of characters	1 4	4	I4
Characters	5 12	8	2A4
Other Records			
Characters	1 12	12	3A4
5. Message			
First Record			
M	1	1	A1
Message Number	2 3	2	I2
Blanks	4 10	7	7X
Number of Characters	11 12	2	I2
Other Records			
Characters	1 12	12	3A4
6. Flash a Symbol			
F			A1
Flash numbers			I6
Blanks			2X
ISYM			I3
Second Record			
X, Y			2I6

E. DAHLGREN Format

Record size is 80 characters. For the sign of latitude, a one is negative, a zero is positive and a seven is a new line.

Fld. No.	Field Name	Format	Description of Data	Col. Pos.	Fld. Len.
First Record in a Block					
1	DECK	I4	Always value 2520	1 4	4
2	BLOCK	I4	Block value	5 8	4
3	RECORD	I3	Record value	9 11	3
4	BLANK	8X	Blank	12 19	8
5	S	I4	Number of points	20 23	4
6	BLANK	4X	Blank	24 27	3
7	SLAT (1)	I1	Sign of Latitude	28	1
8	LATD (1)	F3.0	Latitude degree part	29 31	3
9	LATM (1)	F4.0	Latitude minute part	32 35	4
10	SLON (1)	I1	Sign of Longitude	36	1

Fld. No.	Field Name	Format	Description of Data	Col. Pos.	Fld. Len.
11	LOND (1)	F3.0	Longitude degree part	37 39	3
12	LONM (1)	F4.0	Longitude minute part	40 43	4
13	SLAT (2)	I1	Sign of Latitude	44	1
14	LATD (2)	F3.0	Latitude degree part	45 47	3
15	LATM (2)	F4.0	Latitude minute part	48 51	4
16	SLON (2)	I1	Sign of Longitude	52	1
17	LOND (2)	F3.0	Longitude degree part	53 55	3
18	LONM (2)	F4.0	Longitude minute part	56 59	4
19	SLAT (3)	I1	Sign of Latitude	60	1
20	LATD (3)	F3.0	Latitude degree part	61 63	3
21	LATM (3)	F4.0	Latitude minute part	64 67	4
22	SLON (3)	I1	Sign of Longitude	68	1
23	LOND (3)	F3.0	Longitude degree part	69 71	3
24	LONM (3)	F4.0	Longitude minute part	72 75	4

All Other Records in a Block

Fld. No.	Field Name	Format	Description of Data	Col. Pos.	Fld. Len.
1	DECK	I4	Always value 252	1 4	4
2	BLOCK	I4	Block value	5 8	4
3	RECORD	I3	Record value	9 11	3
4	SLAT (1)	I1	Sign of Latitude	12	1
5	LATD (1)	F3.0	Latitude degree part	13 15	3
6	LATM (1)	F4.0	Latitude minute part	16 19	4
7	SLON (1)	I1	Sign of Longitude	20	1
8	LOND (1)	F3.0	Longitude degree part	21 23	3
9	LONM (1)	F4.0	Longitude minute part	24 27	4
10	SLAT (2)	I1	Sign of Latitude	28	1
11	LATD (2)	F3.0	Latitude degree part	29 31	3
12	LATM (2)	F4.0	Latitude minute part	32 35	4
13	SLON (2)	I1	Sign of Longitude	36	1
14	LOND (2)	F3.0	Longitude degree part	37 39	3
15	LONM (2)	F4.0	Longitude minute part	40 43	4
16	SLAT (3)	I1	Sign of Latitude	44	1
17	LATD (3)	F3.0	Latitude degree part	45 47	3
18	LATM (3)	F4.0	Latitude minute part	48 51	4
19	SLON (3)	I1	Sign of Longitude	52	1
20	LOND (3)	F3.0	Longitude degree part	53 55	3
21	LONM (3)	F4.0	Longitude minute	56 59	4
22	SLAT (4)	I1	Sign of Latitude	60	1
23	LATD (4)	F3.0	Latitude degree part	61 63	3
24	LATM (4)	F4.0	Latitude minute part	64 67	4
25	SLON (4)	I1	Sign of Longitude	68	1
26	LOND (4)	F3.0	Longitude degree part	69 71	3
27	LONM (4)	F4.0	Longitude minute part	72 75	4

IV. EQUIPMENT SPECIFICATION AND STORAGE

The CAM program will operate on an IBM 360 computer with a Fortran IV level G or H compiler and 512 bytes of core with at least one tape unit. The program uses approximately 250,000 bytes of core. This includes the plotter software for the Calcomp 1136 and the Gerber 1232. This program will also operate on non-IBM/360 computers if the ALC subroutines ADATA and ALFIE are rewritten.

V. MATHEMATICAL MODEL

A. Definitions

ρ The latitude of a point whose projection coordinates are desired.

μ The longitude of a point whose projection coordinates are desired.

X_m Abscissa of a plane cartesian coordinate system—unscaled.

Y_m The ordinate of a plane cartesian coordinate system—unscaled.

E_e The eccentricity of the earth.

r The radial distance of a plane polar coordinate system.

θ The angular direction of a plane polar coordinate system.

ρ_o The latitude of the center of the map.

μ_o Longitude of the center of the map—the central meridian for conic projections.

x_m Abscissa of a plane cartesian coordinate system—scaled. (inches.)

y_m The ordinate of a plane cartesian coordinate system—scaled. (inches.)

Δ_μ The longitude referenced to the central meridian. $\Delta\mu = \mu - \mu_o$

ρ_{sp1} The lower (southerly) standard parallel for projection having two standard parallels or the standard parallel for projection having one standard parallel.

ρ_{sp2} The upper (northerly) standard parallel for projection having two standard parallels.

r_1 The radial distance from the origin to the image of the southerly standard parallel in plane polar coordinates.

ℓ The constant of the cone for conic projections.

k The constant of integration for conic projections.

a Radius of the earth in nautical miles.

A Major axis of Spheroid (meters)

B Minor axis of Spheroid (meters)

C_m Central Meridian

h_o Height of the observation point for the Perspective Projection.

X_s Scale factor in the x direction.

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Y_s Scale factor in the y direction.

ρ_t True scale latitude.

c_f Number of inches in a nautical mile.

$s_{\rho t}$ Map scale at true scale latitude.

All angular values are assumed to be in radians. Conversion to scale can be achieved by multiplying all distances by the appropriate scale factor. North latitudes and east longitudes are taken to be positive, i.e. See Figure 2.

$$-\pi/2 \leq \rho \leq +\pi/2$$
$$-\pi \leq \mu \leq +\pi$$

B. Map Projection Equations

1. Cylindrical Projections

a. Equirectangular

$$Y_m = \rho - \rho_o$$

$$X_m = \Delta\mu$$

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$

b. Mercator

$$X_m = \Delta\mu$$

$$Y_m = \ln\left[\tan\left(\frac{\pi}{4} + \frac{|\rho|}{2}\right)\right] + \frac{E\,c}{2}\ln\left[\frac{1 - Ec\sin|\rho|}{1 + Ec\sin|\rho|}\right]$$

Y_m assumes the sign of ρ

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$

c. Miller

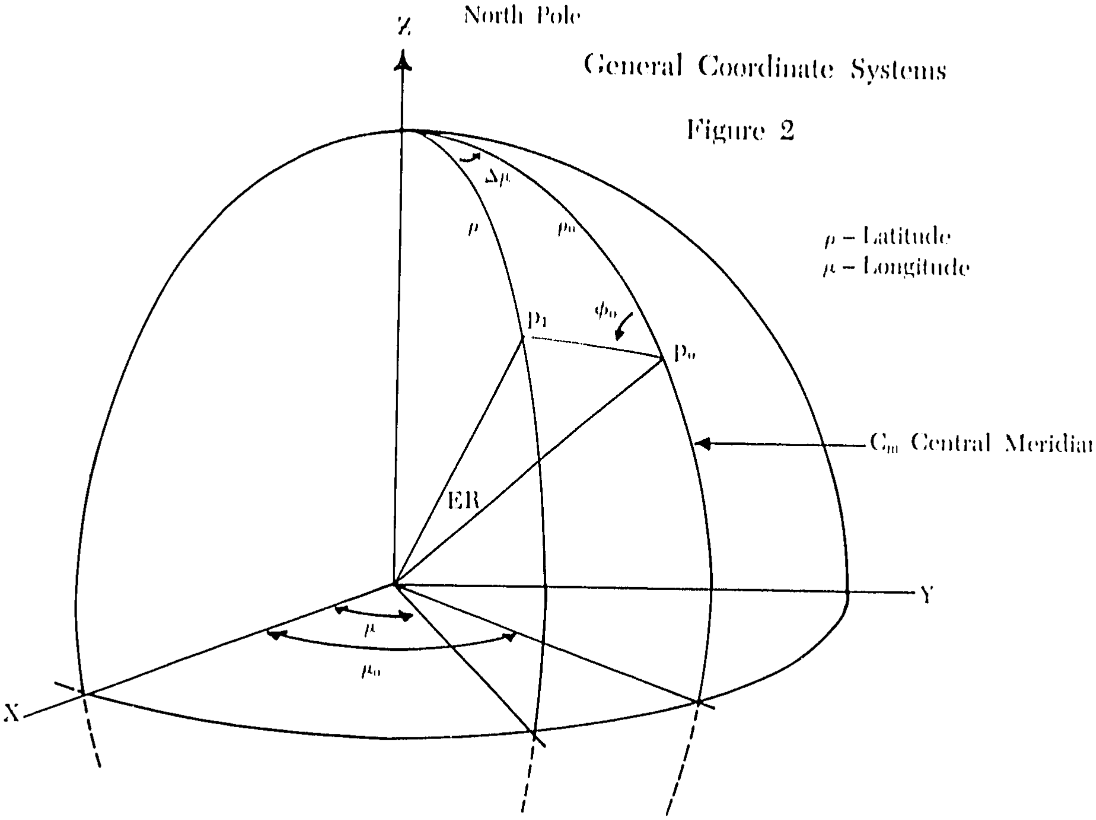
$$X_m = \Delta\mu$$

$$Y_m = \frac{5}{4}\ln\left[\tan\left(\frac{\pi}{4} + \frac{2|\rho|}{5}\right)\right]$$

Y_m assumes the sign of ρ

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$



General Coordinate Systems

Figure 2

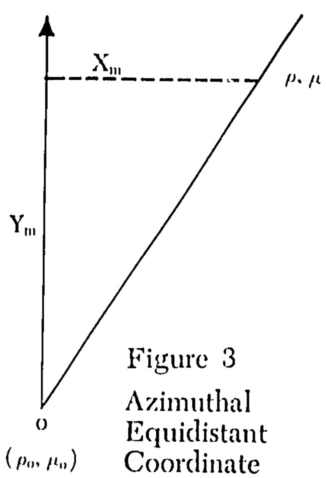
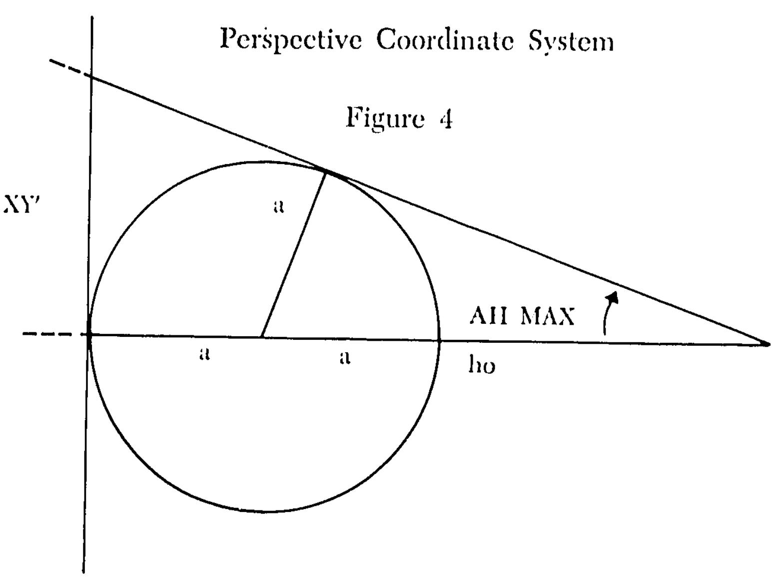


Figure 3
Azimuthal Equidistant Coordinate System



Perspective Coordinate System

Figure 4

d. Transverse Mercator Sphere With Center at 0°N 0°E.

$$X_m = \frac{1}{2} \ln \left[\frac{1 + \cos \rho \sin \Delta \mu}{1 - \cos \rho \sin \Delta \mu} \right]$$

$$Y_m = \tan^{-1} [\tan \rho / \cos |\Delta \mu|] - Y_o$$

$$x_m = X_m \cdot X_o$$

$$y_m = Y_m \cdot Y_o$$

e. Universal Transverse Mercator (UTM)-Spheroid

The following transformation constants are computed only once.

$$(E')^2 = (A^2 - B^2)/B^2$$

$$E^2 = (A^2 - B^2)/A^2$$

$$A_n = (A - B)/(A + B)$$

$$A' = A \cdot \left[1 - A_n + \frac{5}{4}(A_n^2 - A_n^3) + \frac{81}{64}(A_n^4 - A_n^5) \right]$$

$$B' = \frac{3}{2} A \left[A_n - A_n^2 + \frac{7}{8}(A_n^3 - A_n^4) + \frac{55}{64} A_n^5 \right]$$

$$C' = \frac{15}{16} A \left[A_n^2 - A_n^3 + \frac{3}{4}(A_n^4 - A_n^5) \right]$$

$$D' = \frac{35}{48} A \left[A_n^3 - A_n^4 + \frac{11}{16} A_n^5 \right]$$

$$E' = \frac{315}{512} A [A_n^4 - A_n^5]$$

$$Z_{k\phi} = .9996$$

The following equations are used to transform a latitude longitude (ρ, μ) to x_m, y_m.

$$\Delta f = C_m - \mu$$

$$\Delta = |\Delta f|$$

$$S = Z_{k\phi} \cdot [A' \cdot |\rho| - B' \cdot \sin(2 \cdot |\rho|) + C' \cdot \sin (4 \cdot |\rho|) - D' \sin (6 \cdot |\rho|) + E' \sin(8 \cdot |\rho|)]$$

$$V_E = \frac{A}{[1.0 - E^2 \sin^2(|\rho|)]^{1/2}}$$

$$S_R = \frac{V_E}{2} \sin |\rho| \cdot \cos |\rho| \cdot Z_{k\phi}$$

$$S_T = V_E \cdot \sin |\rho| \cdot \cos^3 |\rho| \cdot [5 - \tan^2(|\rho|) + 9 E'^2 \cos^2(|\rho|) + 4 E'^4 \cos^4(|\rho|)] Z_{k\phi}/24$$

$$S_U = V_E \cdot \cos |\rho| \cdot Z_{k\phi}$$

$$S_V = \frac{V_E}{6} \cdot \cos^3 |\rho| \cdot [1 \cdot - \tan^2(|\rho|) + E'^2 \cos^2 |\rho|] \cdot Z_{k\phi}$$

$$S_A = \frac{\Delta^6}{720} \cdot V_E \cdot \sin(|\rho|) \cdot \cos^5(|\rho|) \cdot [61 - 58 \cdot \tan^2(|\rho|)$$
$$+ \tan^4(|\rho|) + 270\, E'^2 \cos^2(|\rho|) - 330 \cdot E'^2 \sin^2(|\rho|)]\, Z_{\phi,\rho}$$

$$S_B = \frac{\Delta^5}{120} \cdot V_E \cdot \cos^5 |\rho| \cdot [5 \cdot - 18 \cdot \tan^2(|\rho|) + \tan^4(|\rho|)$$
$$+ 14 \cdot E'^2 \cos^2(|\rho|) - 58 \cdot E'^2 \sin^2(|\rho|)] \cdot Z_{\phi,\rho}$$

$E_p = S_F \cdot \Delta + S_V \cdot \Delta^3 + S_B$

IF $\Delta_F < o$ $X_m = E_p - X_o$

Otherwise $X_m = -E_p - X_o$

$Y = S + S_R \cdot \Delta^2 + S_T \cdot \Delta^4 + S_A$

IF $\rho < o$ $Y_m = -Y - Y_o$

Otherwise $Y_m = Y - Y_o$

$x_m = X_m \cdot X_s$

$y_m = Y_m \cdot Y_s$

2. Azimuthal Projections

a. Azimuthal-Equal-Area

E_R and ϕ are computed the same as the Azimuthal Equidistant projection.

$$X_m = 2 \cdot \sin\left(\frac{E_R}{2}\right) \sin\phi$$

$$Y_m = 2 \cdot \sin\left(\frac{E_R}{2}\right) \cos\phi$$

$x_m = X_m \cdot X_s$

$y_m = Y_m \cdot Y_s$

b. Azimuthal Equidistant

$\Delta\mu = \mu - \mu_o$

$E_R = \cos^{-1}[\cos\rho_o \cos\rho + \sin\rho_o \sin\rho \sin|\Delta\mu|]$

$$\phi_o = \cos^{-1}\left[\frac{\cos\rho_o - \cos E_R \cos\rho}{\sin E_R \sin\rho_o}\right]$$

For $\Delta\mu > o$, $\phi = \phi_o$

For $\Delta\mu < o$, $\phi = \pi - \phi_o$

$X_m = E_R \sin\phi$

$Y_m = E_R \cos\phi$

$x_m = X_m \cdot X_s$

$$y_m = Y_m \cdot Y_s$$

See Figure 2 and Figure 3.

c. Gnomonic

$$X_m = \left[\frac{\cos \rho \sin \Delta \mu}{\sin \rho \sin \rho_o + \cos \rho \cos \rho_o \cos \Delta \mu}\right]$$

$$Y_m = \left[\frac{\sin \rho \cos \rho_o - \sin \rho_o \cos \rho \cos \Delta \mu}{\sin \rho \sin \rho_o + \cos \rho \cos \rho_o \cos \Delta \mu}\right]$$

$$x_m = X_m \cdot X_s$$

$$y_m = Ym \cdot Y_m$$

d. Orthographic

Compute E_R and the azimuth angle (ϕ) the same as the Azimuthal Equidistant Projection.

$$X_m = \sin E_R \sin \phi$$

$$Y_m = \sin E_R \cos \phi$$

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$

Note: This projection is valid only for $E_R \leq \pi/2$.

e. Perspective

Compute E_R and the azimuth angle (ϕ) the same as the Azimuthal Equidistant Projection.

$$R_{SL} = [a^2 + (a+h)^2 - 2 \cdot a \cdot (a+h) \cos E_R]^{1/2}$$

$$AH = \sin^{-1}\left[\frac{a \sin E_R}{R_{SL}}\right]$$

$$XY = \tan(AH) \cdot (2a+h)$$

$$X_m = XY \sin \phi$$

$$Y_m = XY \cos \phi$$

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$

Note: This projection is valid for E_R's less than the earth center angle from 'line to observation point' and the horizon.

$E_R \leq E_{RMAX}$, where $E_{RMAX} = \cos^{-1}\left[\frac{a}{a+h}\right]$ See Figure 4.

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f. Stereographic

$$X_m = \left[\frac{\cos \rho \sin \Delta\mu}{1.0 + \sin \rho \sin \rho_o + \cos \rho \cos \rho_o \cos\Delta\mu}\right] \cdot \left[\frac{1 - E_e \sin (|\rho|)}{1 + E_e \sin (|\rho|)}\right]^{\frac{E_e}{2}}$$

$$Y_m = \left[\frac{\sin \rho \cos \rho_o - \sin \rho_o \cos \rho \cos\Delta\mu}{1.0 + \sin \rho \sin \rho_o + \cos \rho \cos \rho_o \cos\Delta\mu}\right] \cdot \left[\frac{1 - E_e \sin (|\rho|)}{1 + E_e \sin (|\rho|)}\right]^{\frac{E_e}{2}}$$

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$

3. Conic Projections

a. Conic projections are divided into three functional groups—conformal, equal interval, and equal area. Within each group the general equations of transformation remain the same. The type of projection determines the transformation constants (ℓ, k, r_o). The scale is calculated the same for all conics.

b. Conformal Conic (Lambert)

1) General transformation, given ℓ, k, r_o.

$$\tan \frac{Z_m}{2} = \left[\cot\text{an} \left(\frac{\pi}{4} + \frac{\text{Pole} \cdot \rho}{2}\right)\right] \cdot \left[\frac{1 + E_e \sin \rho}{1 - E_e \sin \rho}\right]^{\frac{E_e}{2}}, \text{ where}$$

Pole = 1.0, Cone over North Pole

Pole = −1.0, Cone over South Pole

$$r_m = |k \tan^{\ell}(Z_m/2)$$

$$X_m = r_m \sin (\ell \cdot |\Delta\mu|)$$

if Pole < 0 and $\Delta\mu > 0$, $X_m = -X_m$

if Pole ≥ 0 and $\Delta\mu < 0$, $X_m = -X_m$

$$Y_m = r_o - r_m \cos (\ell \cdot |\Delta\mu|)$$

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$

2) The transformation constants (ℓ, k, r_o) for the Lambert Projection; given the two standard parallels, the central meridian (μ_o) and the origin parallel (ρ_o).

$$\tan \frac{Z_o}{2} = \left[\cot\text{an} \left(\frac{\pi}{4} + \frac{\text{Pole} |\rho_o|}{2}\right)\right] \cdot \left[\frac{1 + E_e \sin \rho_o}{1 - E_e \sin \rho_o}\right]^{\frac{E_e}{2}}$$

$$\tan \frac{Z_1}{2} = \left[\cot\text{an} \left(\frac{\pi}{4} + \frac{\text{Pole} |\rho_{sp1}|}{2}\right)\right] \cdot \left[\frac{1 + E_e \sin \rho_{sp1}}{1 - E_e \sin \rho_{sp1}}\right]^{\frac{E_e}{2}}$$

$$\tan \frac{Z_2}{2} = \left[\cot\left(\frac{\pi}{4} + \frac{\text{Pole}\,|\rho_{sp2}|}{2}\right)\right] \cdot \left[\frac{1+E_e \sin \rho_{sp2}}{1-E_e \sin \rho_{sp2}}\right]^{\frac{E_e}{2}}$$

$$N_1 = a/(1-E_e^2 \sin^2 \rho_{sp1})^{1/2}$$

$$N_2 = a/(1-E_e^2 \sin^2 \rho_{sp2})^{1/2}$$

$$\ell = \frac{\ln(\cos \rho_{sp1}) - \ln(\cos \rho_{sp2}) + \ln(N_1) - \ln(N_2)}{\ln\left(\tan \frac{Z_1}{2}\right) - \ln\left(\tan \frac{Z_2}{2}\right)}$$

$$\ell = |\ell|$$

$$k = \frac{1}{2}\left[\frac{N_1 \cos \rho_{sp1}}{\tan^{\ell}\left(\frac{Z_1}{2}\right)} + \frac{N_2 \cos \rho_{sp2}}{\ell \tan^{\ell}\left(\frac{Z_2}{2}\right)}\right]$$

$$r_o = k \tan^{\ell}\left(\frac{Z_o}{2}\right)$$

c. Conic Equal-Interval (Ptolemy, Kavraiskiy IV)

1) Equations for the general transformation from latitude and longitude to x, y given ℓ, k, r_o.

$$r_m = k - a \cdot \rho$$

$$X_m = r_m \cdot \sin(\ell \cdot \Delta\mu)$$

$$Y_m = r_o - r_m \cos(\ell \cdot \Delta\mu)$$

$$x_m = X_m \cdot X_s$$

$$y_m = Y_m \cdot Y_s$$

2) The transformation constants for the Ptolemy Projection.

$$\ell = \sin \rho_{sp1}$$

$$k = a\,[\cot(\rho_{sp1}) + \rho_{sp1}]$$

$$r_o = k - a \cdot \rho_o$$

3) The transformation constants for The Kavraiskiy IV Projection.

$$\ell = \frac{\cos \rho_{sp1} - \cos \rho_{sp2}}{\rho_{sp2} - \rho_{sp1}}$$

$$k = \frac{a}{2}\left[\frac{\cos \rho_{sp1}}{\ell} + \rho_{sp2} + \frac{\cos \rho_{sp2}}{\ell} + \rho_{sp2}\right]$$

$$r_o = k - a \cdot \rho_o$$

d. Conic Equal-Area (Albers)

1) Transformation from latitude and longitude to x, y, given ℓ, k, r_o.

$$\sin B=\sin \rho\left[\frac{1.0+\frac{2}{3}E_e^2 \sin^2 \rho+\frac{3}{5}E_e^4 \sin^4 \rho+\frac{4}{7}E_e^6 \sin^6 \rho}{1.0+\frac{2}{3}E_e^2+\frac{3}{5}E_e^4+\frac{4}{7}E_e^6}\right]$$

$$r_m=\left[k^2+\frac{2\cdot c^2}{\ell}(\sin B_1-\sin B)\right]^{1/2}$$

$$x=r_m \sin(\ell\cdot\Delta\mu)$$

$$y=r_o-r_m \cos \rho$$

2) The transformation constants for the Albers Conic Equal-Area.

$$\ell=\frac{\dfrac{a^2\cos^2\rho_{sp1}}{(1-E_e^2\sin^2\rho_{sp1})}-\dfrac{a^2\cos^2\rho_{sp2}}{(1-E_e^2\sin^2\rho_{sp2})}}{2\cdot c^2\ (\sin B_2-\sin B_1)}$$

where $\sin B_1$, $\sin B_2$, and c^2 equal the following:

$$\sin B_1=\sin \rho_{sp1}\left[\frac{1.0+\frac{2}{3}E_e^2 \sin^2 \rho_{sp1}+\frac{3}{5}E_e^4 \sin^4 \rho_{sp1}+\frac{4}{7}E_e^6 \sin^6 \rho_{sp1}}{1.0+\frac{2}{3}E_e^2+\frac{3}{5}E_e^4+\frac{4}{7}E_e^6}\right]$$

$$\sin B_2=\sin \rho_{sp2}\left[\frac{1.0+\frac{2}{3}E_e^2 \sin^2 \rho_{sp2}+\frac{3}{5}E_e^4 \sin^4 \rho_{sp2}+\frac{4}{7}E_e^6 \sin^6 \rho_{sp2}}{1.0+\frac{2}{3}E_e^2+\frac{3}{5}E_e^4+\frac{4}{7}E_e^6}\right]$$

$$c^2=a^2\ (1.0-E_e^2)\left[\frac{.5}{(1.-E_e^2)}+\left(\frac{.25}{E_e}\log_e\left(\frac{1+E_e}{1-E_e}\right)\right)\right]$$

$$k=\frac{a\cos\rho_{sp1}}{\ell(1.-E_e^2\sin^2\rho_{sp1})^{1/2}}$$

$$\mathrm{Sin}\ B_o=\sin \rho_o\left[\frac{1.0+\frac{2}{3}E_e^2 \sin^2 \rho_o+\frac{3}{5}E_e^4 \sin^4 \rho_o+\frac{4}{7}E_e^6 \sin^6 \rho_o}{1.0+\frac{2}{3}E_e^2+\frac{3}{5}E_e^4+\frac{4}{7}E_e^6}\right]$$

$$r_o=\left[k^2+\frac{2c^2}{\ell}(\sin B_1-\sin B_o)\right]^{1/2}$$

4. Miscellaneous

a. Polyconic

The following transformation constants are computed only once.

$$E^2 = (A^2 - B^2)/A^2$$

$$A_n = (A - B)/(A + B)$$

$$A' = A \cdot \left[1 - A_n + \frac{5}{4}(A_n^2 - A_n^3) + \frac{81}{64}(A_n^4 - A_n^5)\right]$$

$$B' = \frac{3}{2} A \left[A_n - A_n^2 + \frac{7}{8}(A_n^3 - A_n^4) + \frac{55}{64} A_n^5\right]$$

$$C' = \frac{15}{16} A \left[A_n^2 - A_n^3 + \frac{3}{4}(A_n^4 - A_n^5)\right]$$

$$D' = \frac{35}{48} A \left[A_n^3 - A_n^4 + \frac{11}{16} A_n^5\right]$$

$$E' = \frac{315}{512} A \ [A_n^4 - A_n^5]$$

The following equations are used to transform a latitude longitude (ρ, μ) to x_m, y_m.

$$\Delta_f = c_m - \mu$$

$$\Delta = |\Delta f|$$

$$S = [A' \cdot |\rho| - B' \cdot \sin(2 \cdot |\rho|) + C' \cdot \sin(4 \cdot |\rho|) - D'$$

$$\sin(6 \cdot |\rho|) + E' \sin(8 \cdot |\rho|)]$$

$$RH = AA/(1.0 - E^2 \cdot \sin(2 \cdot |\rho|))$$

Case when $|\rho| > 0$.

$$\rho\theta = \Delta \cdot \sin(|\rho|)$$

$$X_L = RH \cdot \cos(|\rho|)/\sin(|\rho|)$$

$$Y = S + 2 \cdot XL \cdot (\sin(\theta/2))^2$$

$$X = XL \cdot \sin(\theta)$$

Case when $\rho = 0$

$$Y = 0.$$

$$X = AA \cdot \Delta$$

Assign proper sign to X and Y

$\Delta f < 0.,\ X_m = X - X_o$

$\Delta f \geq 0.,\ X_m = -X - X_o$

$\rho < 0.,\ Y_m = -Y - Y_o$

$\rho \geq 0.,\ Y_m = Y - Y_o$

$x_m = X_m \cdot X_s$

$y_m = Y_m \cdot Y_s$

b. Sinusoidal

$X_m = \Delta\mu \cdot \cos(\rho)$

$Y_m = \rho$

$x_m = X_m \cdot X_s$

$y_m = Y_m \cdot Y_s$

c. XY Display

$X_m = \Delta\mu$

$Y_m = \rho$

$x_m = X_m \cdot X_s$

$y_m = Y_m \cdot Y_s$

C. Map Scale Factors

1. Cylindrical Projections

a. Equirectangular

$$X_s = \frac{2 \cdot X_{LEN}}{(\mu_{RGT} - \mu_{LFT})}$$

$$Y_s = \frac{2 \cdot Y_{LEN}}{(\rho_{UP} - \rho_{LOW})}$$

b. Mercator, Miller, Transverse Mercator

$k_{\rho t} = [1.0 - E_e^2 \sin \rho_t]^{1/2} / \cos \rho_t$

$s_o = s_{\rho t} \cdot k_{\rho t}$

$$C_{NOM} = D_{NOM} = \frac{c_f \cdot a}{s_o}$$

If scale calibration is not desired

$X_s = C_{NOM}$

$Y_s = D_{NOM}$

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If scale calibration is used, the latitude, longitude, and x and y distances from map center are required for two points—A and B. It is best to have point A in upper right hand quadrant of map and point B in the lower left.

$x_c = C_{NOM}$ (transform of ρ_a)

$y_c = D_{NOM}$ (transform of ρ_a)

$x_d = C_{NOM}$ (transform of ρ_b)

$y_d = D_{NOM}$ (transform of ρ_b)

$$X_s = C_{NOM} \cdot \left[\frac{x_b - x_a}{x_d - x_c}\right]$$

$$Y_s = D_{NOM} \cdot \left[\frac{y_b - y_a}{y_d - y_c}\right]$$

c. Universal Transverse Mercator

$$C_{NOM} = \frac{39.37}{s_{pt}}$$

remainder same as b. above.

2. Azimuthal Projections

a. Azimuthal Equal-Area

$$X_s = \frac{P_r}{2 \sin\left(\frac{R_{MAX}}{2a}\right)}$$

$Y_s = X_s$

b. Azimuthal Equidistant

$$X_s = \frac{a \cdot P_r}{RGE_{MAX}}$$

$Y_s = X_s$ where P_r equals the radius in inches of the plot, and RGE_{MAX} is the maximum range in nautical miles to be plotted.

c. Gnomonic—Same as Mercator (C.1.b.)

d. Orthographic

$X_s = P_r$

$Y_s = X_s$

e. Perspective

$$AH_{MAX} = \sin^{-1}\left[\frac{a}{a+h_a}\right]$$

$$XY' = \tan\left(AH_{MAX}\right) \cdot \left(2a+h_a\right)$$

$$X_s = \frac{P_r}{XY'}$$

$$Y_s = X_s$$

See Figure 4 for definition of AH_{MAX} and XY'.

f. Stereographic

$$X_s = \frac{P_r}{\tan\left(\frac{R_{MAX}}{2a}\right)}$$

$$Y_s = X_s$$

3. Conic Projections

$$C_{NOM} = D_{NOM} = \frac{c_r}{s_m}$$

If no scale calibration

$$X_s = C_{NOM}$$
$$Y_s = D_{NOM}$$

If scale calibration

$x_c = C_{NOM}$ (transform of ρ_a)
$y_c = D_{NOM}$ (transform of ρ_a)
$x_d = C_{NOM}$ (transform of ρ_b)
$Y_d = D_{NOM}$ (transform of ρ_b)

$$X_s = C_{NOM} \cdot \left[\frac{x_b - x_a}{x_d - x_c}\right]$$

$$Y_s = D_{NOM} \cdot \left[\frac{y_b - y_a}{y_d - y_c}\right]$$

4. Miscellaneous

a. XY Display

$$X_s = 1.0$$
$$Y_s = 1.0$$

b. Polyconic—Same Universal Transverse Mercator (C.1.c.)

c. Sinusoidal—Same as Mercator (C.1.b.)

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VI. DESCRIPTION OF PROGRAM VARIABLES

A. Arrays (DUM1 and SAVE) for Storage of Input Values

Location	Variable	Units	Description
1	ECCEN		Eccentricity of the earth
2	RADE	Nautical Miles	Radius of the Earth
3	SADEMR		Map Scale
4	CONFAC		The conversion factor to go from map units to earth units 72960 inches in a nautical mile or 39.37 inches in a meter
5	ICALIB	0 or 1	Map scale calibration control parameter 0, no calibration 1, scale is calibrated by two points from the map. Values for locations 12 to 27 must be given.
6	RHO0D	Degrees	Latitude of map origin, Degree part. North is plus and south is minus.
7	RHO0M	Minutes	Latitude of map origin, Minute part
8	RHO0S	Seconds	Latitude of map origin, Second part
9	XMU0D	Degrees	Longitude of map origin, Degree part
10	XMU0M	Minutes	Longitude of map origin, Minute part
11	XMU0S	Seconds	Longitude of map origin, Second part
12	SYA	Inches	Y - distance from map origin to point A
13	SXA	Inches	X - distance from map origin to point A
14	SYB	Inches	Y - distance from map origin to point B
15	SXB	Inches	X - distance from map origin to point B
16	RHOAD	Degrees	Latitude of point A, Degree part
17	RHOAM	Minutes	Latitude of point A, Minute part
18	RHOAS	Seconds	Latitude of point A, Second part
19	XMUAD	Degrees	Longitude of point A, Degree part
20	XMUAM	Minutes	Longitude of point A, Minute part
21	XMUAS	Seconds	Longitude of point A, Second part
22	RHOBD	Degrees	Latitude of point B, Degree part
23	RHOBM	Minutes	Latitude of point B, Minute part
24	RHOBS	Seconds	Latitude of point B, Second part
25	XMUBD	Degrees	Longitude of point B, Degree part
26	XMUBM	Minutes	Longitude of point B, Minute part
27	XMUBS	Seconds	Longitude of point B, Second part
28	TSLATD	Degrees	True scale latitude, Degree part
29	TSLATM	Minutes	True scale latitude, Minute part
30	TSLATS	Seconds	True scale latitude, Second part
31	TPLOT		Control parameter for subroutine RYTOUT =1, Only valid value
32	NTAP	—	Data set reference number for plotter output
33	NDAT	—	Data set reference number for data to be symbol plotted
34	NDAT2	—	Data set reference number for data to be line plotted

Location	Variable	Units	Description
35	ICOLIN		Line Control Parameter to indicate the format type of user line data 0, no data 1, 80 character World Data Bank Format radians 2, 22 Byte Binary World Data Bank Format 3, Graphic Data Format 4, Not used 5, 80 character World Data Bank Format degrees, minutes, seconds 6, Dahlgren 7, Trace I Format 8, Not used 9, 8 Byte World Data Base II Format direct access
36	XLIM	Inches	Distance from the center of the plot to the right margin
37	YLIM	Inches	Distance from the center of the plot to the top margin
38	IOVRLY		Overlay control parameter =0, No overlay =1, Line grid =2, Not used =3, Range Rings =4, Circle =5, Azimuths & Elevation Rings =6, Box =7, Ellipse =8, Great Circle =9, Range Box =10, Not used =11, Area fill =12, UTM Grid =13, Lat/Long tick =14, UTM Meter tick =15, Corridor
39	ISYMPT		Symbol control parameter =0, No symbols =1, Trace I Format. It puts the symbol "." at each point. =2, MBFMT format =3, 80 character World Data Bank I Format—radians =4, 22 Byte Binary World Data Bank I Format =5, Graphic Data Format =6, Not used =7, 80 character World Data Bank I Format—degrees, minutes, seconds =8, Not used =9, Trace I format

Location	Variable	Units	Description
			10, not used 11, 8 Byte World Data Base II Format
40	RHOLWD	Degrees	Latitude of Lower Map Boundary, degree part
41	RHOLWM	Minutes	Latitude of Lower Map Boundary, minute part
42	RHOLWS	Seconds	Latitude of Lower Map Boundary, second part
43	RHOUPD	Degrees	Latitude of Upper Map Boundary, degree part
44	RHOUPM	Minutes	Latitude of Upper Map Boundary, minute part
45	RHOUPS	Seconds	Latitude of Upper Map Boundary, second part
46	XMULD	Degrees	Longitude of Left Map Boundary, degree part
47	XMULM	Minutes	Longitude of Left Map Boundary, minute part
48	XMULS	Seconds	Longitude of Left Map Boundary, second part
49	XMURD	Degrees	Longitude of Right Map Boundary, degree part
50	XMURM	Minutes	Longitude of Right Map Boundary, minute part
51	XMURS	Seconds	Longitude of Right Map Boundary, second part
52	PTOL	Inches	Minimum distance between consecutive points on the plot
53	MAP		Map Projection Control Parameter =1, Mercator =2, Miller Cylindrical =3, Transverse Mercator =4, XY Display =5, Azimuthal Equidistant =6, Orthographic =7, Equirectangular =8, Stereographic =9, Universal Transverse Mercator Spheroid (UTM) =10, Gnomonic =11, Lambert =21, Ptolemy =22, Kavraiskiy IV =31, Albers =40, Perspective =41, Azimuthal Equal-Area =42, Sinusoidal =43, Polyconic

Location	Variable	Units	Description
54	RSP1D	Degrees	Latitude of Lower Standard Parallel, Degree part
55	RSP1M	Minutes	Latitude of Lower Standard Parallel, Minute part
56	RSP1S	Seconds	Latitude of Lower Standard Parallel, Second part
57	RSP2D	Degrees	Latitude of Upper Standard Parallel, Degree part
58	RSP2M	Minutes	Latitude of Upper Standard Parallel, Minute part
59	RSP2S	Seconds	Latitude of Upper Standard Parallel, Second part
60	CONSTL		• The constant of the cone for conic projections. It must be given if ILK = 1, or • Distance from center point to right boundary for Rectangular projection.
61	CONSTK		• The constant of integration for conic projections. It must be given if ILK = 1, or • Distance from center point to upper boundary for Rectangular projection.
62	ILK	0 or 1	Control parameter for the calculation of CONSTL and CONSTK = 0, The program will compute them, using the standard parallels (RSP1 and RSP2) = 1, User must input the values of CONSTL and CONSTK
63	XMUINT	Degrees	The interval between meridians for line grids; i.e., meridians will be drawn every XMUINT degrees. If this value is less than or equal to zero, meridians will not be drawn.
64	RHOINT	Degrees	The interval between parallels for line grids; i.e., parallels will be drawn every RHOINT degrees. If this value is less than or equal to zero, parallels will not be drawn.
65	DXMU1	Degrees	The degree increment used for generating points to define the parallels for line grid
66	DRHO1	Degrees	The degree increment used for generating points to define the meridians for line grid
67	BXLFT	Inches	Distance to left side of box from map center (0,0)
68	BXBOT	Inches	Distance to bottom side of box from map center (0,0)
69	BXRGT	Inches	Distance to right side of box from map center (0,0)

Location	Variable	Units	Description
70	BXTOP	Inches	Distance to top side of box from map center (0,0)
71	XOFF	Inches	X offset. Plus moves the origin to the right and minus to the left.
72	YOFF	Inches	Y offset. Plus moves the origin up and minus moves it down.
73	PTOL2	Inches	The maximum distance allowed between consecutive points before the pen is lifted. The default value is 4.0.
74	IPEN	1 24	Pen or aperture to be used
75	IHGT	0.01″	Height of the symbols to be drawn in multiples of 0.01 inches. Example a value of 10. gives .1 inches.
76	IANGLE	Degrees	The angle at which symbols are drawn
77	ISORL	0 3	Control parameter for symbols 0, User plotter manufacturer's software to generate symbol 1, Draws the symbol by the standard symbol generator software 2, Flashes the symbol 3, Selects the symbol from the symbol table
78	RRAZD	Degrees	Angular increment used to generate circles, cone, ellipses or range ranges
79	RR		Radius of range ring or ellipse in nautical miles, radius of circle in inches, or angle in degrees for area fills
80	TICKAZ	Degrees	Control parameter for tick marks on the range ring or circle
81	TLENG		Length of tick marks in inches on the range ring or circle. Or the area fill option.
82	CPIP4		Not used
83	RANMAX	Nautical Miles	Radius of Azimuthal Equidistant, Azimuthal Equal-Area or Stereographic Projections
84	RHOCD	Degrees	Latitude of center for azimuths, boxes, circles, elevation rings, ellipses, or range rings degree part
85	RHOCM	Minutes	Latitude of center for azimuths, boxes, circles, elevation rings, ellipses, or range rings minute part
86	RHOCS	Seconds	Latitude of center for azimuths, boxes, circles, elevation rings, ellipses, or range rings second part
87	XMUCD	Degrees	Longitude of center for azimuths, boxes, circles, elevation rings, ellipses, or range rings—degree part
88	XMUCM	Minutes	Longitude of center for azimuths, boxes, circles, elevation rings, ellipses, or range rings—minute part

Location	Variable	Units	Description
89	XMUCS	Seconds	Longitude of center for azimuths, boxes, circles, elevation rings, ellipses, or range rings—second part
90	XWRD		Not used
91	AZDMIN	Nautical Miles	The distance from the center point of BODE to start azimuth lines
92	AZDMAX	Nautical Miles	The distance from the center point of BODE to terminate the azimuth lines
93	AZDDEL	Nautical Miles	The increment used for generating points in the azimuth lines
94	AZDEL	Degrees	Azimuth lines are drawn every AZDEL degrees. If less than or equal to zero, no azimuths will be drawn.
95	SATALT	Nautical Miles	Altitude for elevation rings
96	STALT	Feet	Height of the BODE center point above sea level
97	ELO	Degrees	Elevation angle to start elevation rings
98	ELMAX	Degrees	Elevation angle to terminate elevation rings
99	DEL	Degrees	Elevation angle increment; i.e., elevation rings are drawn every DEL degrees. If this value is less than or equal to zero, no elevation rings are drawn.
100	ELAZD	Degrees	Angular increment used to generate points in the elevation rings
101	DTIC	Nautical Miles	Tick marks are placed every DTIC nautical miles on given azimuths. If this value is less than or equal to zero, no ticks are drawn.
102	DAZTIC	Degrees	Tick marks are placed on every DAZTIC azimuth
103	AZMIN	Degrees	The angle from North to start drawing azimuth lines, ellipses, elevation rings, or range rings
104	AZMAX	Degrees	The angle from North to terminate drawing azimuth lines, ellipses, elevation rings, or range rings
105	A	Meters	Semi-major axis of spheroid
106	B	Meters	Semi-minor axis of spheroid
107	CMD	Degrees	Central meridian for the Transverse Mercator Spheroid Projection (UTM), degree part
108	CMM	Minutes	Central meridian for the Transverse Mercator Spheroid Projection (UTM), minute part
109	CMS	Seconds	Central meridian for the Transverse Mercator Spheroid Projection (UTM), second part

Location	Variable	Units	Description
110	RRMAX		• Radius in nautical miles of last range ring, or • Semi-major axis of ellipse in nautical miles, or • Format type for input to area fill
111	DELRR		• Range rings are drawn every DELRR nautical mile, or • Nautical mile increment used to generate points in the sides of a "Range box", or • Semi-minor axis of ellipse in nautical miles, or • Distance in inches between lines in area fill, or • Nautical mile increment used to generate points in great circles
112	ISCRIB		Control Parameter =0, positive plot image =1, negative plot image
113	ORHALT	Nautical Miles	The altitude above sea level for the Perspective Projection
114	ICORN		Control Parameter for corner ticks =0, no corner ticks =1, corner ticks are drawn
115	ICENT		Control Parameter for center ticks =0, no center ticks =1, center ticks are drawn
116	XDIST		Distance from box center to the right side inches for BOX or nautical miles for BRANGE
117	YDIST		Distance from box center to the top inches for BOX or nautical miles for BRANGE
118	IREG		Control parameter for registry lines =0, no registry lines =1, registry lines are drawn
119	D1	Inches	Distance from the frame (X-limit) to start drawing register lines
120	D2	Inches	Length of register lines
121	OBXSW	---	Open Box option =0, option turned off =1, option turned on
122	ICNTRL	---	Plotter control parameter
123	IRDSRN	---	Data set reference number for range ring centers, great circle points, or ellipse centers
124	IFBXBD	---	Boundary option for open box =0, no boundary =1, boundary is drawn
125	JRANK	---	Rank or class of line to be retrieved
126	LSEQB	---	Beginning (lower) line identifier of lines to be retrieved

Location	Variable	Units	Description
127	LSEQE		Ending (higher) line identifier of lines to be retrieved
128	GLLATD	Degrees	Lower latitude bound for line grid, degree part
129	GLLATM	Minutes	Lower latitude bound for line grid, minute part
130	GLLATS	Seconds	Lower latitude bound for line grid, second part
131	GULATD	Degrees	Upper latitude bound for line grid, degree part
132	GULATM	Minutes	Upper latitude bound for line grid, minute part
133	GULATS	Seconds	Upper latitude bound for line grid, second part
134	GLLOND	Degrees	Left longitude bound for line grid, degree part
135	GLLONM	Minutes	Left longitude bound for line grid, minute part
136	GLLONS	Seconds	Left longitude bound for line grid, second part
137	GRLOND	Degrees	Right longitude bound for line grid, degree part
138	GRLONM	Minutes	Right longitude bound for line grid, minute part
139	GRLONS	Seconds	Right longitude bound for line grid, second part
140	LINMDE		Line mode control parameter for Gerber plotter = 0, solid line = 1, Dash line ( ) = 2, Dash line ( ) = 3, Dash line ( ) = 4, Standard and Broadgauge Railroads ( ) = 5, Narrowgauge Railroads ( ) = 6, Broadgauge Railroads Under Construction ( ) = 7, Narrowgauge Railroads Under Construction ( ) = 8, Sawtoothed line for reefs = 9, Multiple-Track Railroads ( ) = 10, Multiple-Track Railroads Under Construction ( ) = 11, Canals ( ) = 12, Dash line ( )
141	JSYM	—	The location of a symbol in the symbol table
142	VLINMD(1)	—	First parameter for a given line mode
143	VLINMD(2)	—	Second parameter for a given line mode
144	VLINMD(3)	—	Third parameter for a given line mode
145	VLINMD(4)	—	Fourth parameter for a given line mode

Location	Variable	Units	Description
146	VLINMD(5)		Fifth parameter for a given line mode
147	VLINMD(6)		Sixth parameter for a given line mode
148	NSDIR	0 or 1	Control Parameter for the Lambert Conformal Conic when the cone is over the South Pole 0, puts North at the top of map 1, puts South at the top of map
149	CTMED		Zone designation for the central meridian for UTM Grid and UTM Meter Ticks
150	ISPH	1–5	Spheroid for UTM Grid and UTM Meter Ticks =1, International =2, Bessel =3, Everest =4, Clarke, 1866 =5, Clarke, 1880
151	ICORTY		Format type of data used for corridor option
152	CRAZD	Degrees	Angle increment for curves in corridor option
153	CW	Nautical Miles	Width of corridor in nautical miles (from center to one side)
154	ISIDE	0,1,2	Control Parameters for corridor sides =0, corridor on both sides =1, corridor on +90° side only =2, corridor on −90° side only
155	STEP	Nautical Miles	Increment used to step along corridor and sides
156–160	—	—	Not used

B. Parameters in Common Blocks

Block Common	Fortran Variable	Math Symbol	Units	Description
ALTPT	ALTPT	r	Nautical Miles	Earth radius for Perspective Projection
BODE1	AZDMIN	AZD_{MIN}	Nautical Miles	The distance from the center point of BODE to start azimuth lines
	AZDMAX	AZD_{MAX}	Nautical Miles	The distance from the center point of BODE to terminate azimuth lines
	AZDDEL	Δ AZD	Nautical Miles	The increment used for generating points in the azimuth lines
	AZDEL	Δ AZ	Radians	Azimuths lines are drawn every AZDEL radians. If AZDEL is less than or equal to zero, no azimuths will be drawn.
BODE2	ELO	EL_0	Radians	Elevation angle to start elevation rings
	ELMAX	EL_{MAX}	Radians	Elevation angle to terminate elevation rings

Block Common	Fortran Variable	Math Symbol	Units	Description
	DEL	Δ EL	Radians	Elevation angle increment, i.e., elevation rings are drawn every DEL radians. If DEL is less than or equal to zero, no elevation rings are drawn.
	SATALT	SAT_{ALT}	Nautical Miles	Altitude for elevation rings
	STALT	ST_{ALT}	Feet	Height of the BODE center point above sea level
	ELAZD	EL_{AZD}	Radians	Angular increment used to generate points in the elevation rings
BODE3	DTIC	Δ TIC	Nautical Miles	Tick marks are placed every DTIC nautical mile on given azimuths. If DTIC is less than or equal to zero, no ticks are drawn.
	DAZTIC	ΔAZ_{TIC}	Radians	Tick marks are placed on every DAZTIC azimuths
BODE4	AZMIN	AZ_{MIN}	Radians	The angle from North to start drawing azimuth lines, ellipses, elevation rings, or range rings
	AZMAX	AZ_{MAX}	Radians	The angle from North to terminate drawing azimuth lines, ellipses, elevation rings, or range rings
BOXIN	XDIST	XDIST	—	Distance from box center to the right side—inches for BOX or nautical miles for BRANGE
	YDIST	YDIST	—	Distance from box center to the top—inches for BOX or nautical miles for BRANGE
BOXLIM	OBXSW	OBXSW	—	Open Box option
	IFBXBD	IFBXBD	0 or 1	Boundary option for open box
	BXLFT	BXLFT	Inches	Distance to left side of box from map center
	BXBOT	BXBOT	Inches	Distance to bottom side of box from map center
	BXRGT	BXRGT	Inches	Distance to right side of box from map center
	BXTOP	BXTOP	Inches	Distance to top side of box from map center
CARD	NAME(2)	—	—	Eight character input identifier
	VAR(20)	—	—	Input values
	ICON	—	1–20	Number of input values for this name
CETP	YO	Y	—	Unscaled Y of map center
	XO	X_0	—	Unscaled X of map center
CETPOT	RHO0	ρ_0	Radians	Latitude of map origin (central parallel)
	XMU0	μ_0	Radians	Longitude of map origin (central meridian)

Block Common	Fortran Variable	Math Symbol	Units	Description
CLK	CONSTL	ℓ		Constant of the cone for conics
	CONSTK	k	Nautical Miles	Constant of integration for conics
	RO	r_0	Nautical Miles	Conic radius to the latitude of map origin
CNTROL	XOFFL	XOFFL	Inches	X-distance from user origin to the lower left-hand corner
	YOFFL	YOFFL	Inches	Y-distance from user origin to the lower left-hand corner
	XOFFC	XOFFC	Inches	X-distance from user origin to the center of the plot
	YOFFC	YOFFC	Inches	Y-distance from user origin to the center of the plot
CNTRL	PRINT	PRINT		Logical Parameter for plotter debug print = TRUE, Debug print = FALSE, no debug print
	CALD30	CALD30	—	Logical Parameter for Calcomp 1136 Plotter — True or false
	GERBER	GERBER	—	Logical Parameter for Gerber Plotter — True or false
	GRAPDA	GRAPDA	—	Logical Parameter for Graphic Data Format — True or false
CORDR	ICORTY	ICORTY	1–9	Format type of data to be processed for corridor option
	CRAZD	CRAZD	Degrees	Angular increment to step around curves (turns)
	CW	CW	Nautical Miles	Width of corridor
	ISIDE	ISIDE	0–2	Control parameter for corridor = 0, drawn on both sides = 1, drawn on +90° side only = 2, drawn on −90° side only
	STEP	STEP	Nautical Miles	Increment used to generate corridors and center line
CORNTK	ICORN	ICORN	—	Control parameter for corner ticks = 0, no corner ticks = 1, corner ticks
	ICENT	ICENT	—	Control parameter for center + = 0, no + = 1, +
CTPTRR	RHOC	ρ_c	Radians	Latitude of center for range ring, circle, ellipse, box, azimuths, and elevation rings
	XMUC	μ_0	Radians	Longitude of center for range ring, circle, ellipse, box, azimuth and elevation rings
DER	DER	ER_0	Radians	Angular distance between two points. Real*8

Block Common	Fortran Variable	Math Symbol	Units	Description
DISAZ	DIST	D	Nautical Miles	Distance between two points
	AZ	AZ	Radians	Angle from North of the line from one point to another
EC2	EC2	E_c^2		Eccentricity squared
ECCEN	ECCEN	E_c		Eccentricity of the earth
ER	ER	E_R	Radians	Angular distance between two points
GRID1	XMUINT	μINT		Interval between meridians on lat/long grid (degrees), or Longitude interval between ticks on lat/long tick grid (degrees), or Interval between meridians on UTM grid (meters), or Longitude interval between ticks on UTM tick grid (meters)
	RHOINT	ρINT		Interval between parallels on lat/long grid (degrees), or Latitude interval between ticks on lat/long tick grid (degrees), or Interval between Parallel on UTM grid (meters), or Latitude interval between ticks on UTM tick grid (meters)
	DXMU1	$\Delta\mu_1$		Degree increment for generating point to define parallels on lat/long grid Length of tick in longitude direction on lat/long tick grid (seconds), or Meter Increment for generating points to define parallels on UTM grid Length of tick in longitude direction on UTM tick grid (meters)
	DRHO1	$\Delta\rho_1$		Degree increment for generation points to define meridians on lat/long grid, or Length of tick in latitude direction on lat/long tick grid (seconds), or Meter Increment for generating points to define meridians on UTM grid Length of tick in latitude direction on UTM tick grid (meters)
	GRHOLW	GRHOLW	Radians	Lower latitude boundary for the lat/long line grid, lat/long tick grid, UTM grid, or UTM tick grid
	GRHOUP	GRHOUP	Radians	Upper latitude boundary for the lat/long line grid, lat/long tick grid, UTM grid, or UTM tick grid
	GXMULF	GXMULF	Radians	Leftmost longitude boundary for the lat/long line grid, lat/long tick grid, UTM grid, or UTM tick grid
	GXMURG	GXMURG	Radians	Rightmost longitude boundary for the lat/long line grid, lat/long tick grid, UTM grid, or UTM tick grid

Block Common	Fortran Variable	Math Symbol	Units	Description
GRID2	CTMED	CTMED		Zone designation for Central Meridian for UTM grid or UTM meter ticks
	ISPH	ISPH	1–5	Central parameter for the spheroid for the UTM grid or UTM meter ticks
GTMS				Constants for the UTM grid and grid ticks. See common block TMS for a complete description
GUTM	A	A	Meters	Semi-major axis of spheroid for UTM grid and grid ticks
	B	B	Meters	Semi-minor axis of spheroid for UTM grid and grid ticks
	CM	CM	Meters	Central Meridian for UTM grid and grid ticks
ICTPIN	PTOL2	PTOL2	Inches	Maximum distance between consecutive points before the pen is lifted
	IPEN	IPEN	1–24	Pen or aperture
	IHGT	IHGT		Height of symbols to be drawn in 0.01 inches
	IANGLE	IANGLE	Degrees	Angle at which symbols are drawn
ICNTRL	ICNTRL	ICNTRL		Plotter control parameter
IREG	IREG	IREG		Control parameter for registry lines 0, no registry lines 1, registry lines
	D1	D1	Inches	Distance from the frame (X-limit) to start drawing register lines
	D2	D2	Inches	Length of register line
IRDSRN	IRDSRN	IRDSRN		Data set reference number for range ring centers, great circle points, ellipse centers, or corridor line data
ISWAT	ISWAT	ST		Control parameter to indicate that a point is within projection limits = 0, within limits = 1, outside limits
JRANK	LSEQB	LSEQB		Beginning (lower) line identifier of lines to be retrieved
	LSEQE	LSEQE		Ending (higher) line identifier of lines to be retrieved
	JRANK	JRANK		Rank or class of line to be retrieved = 0, all lines are retrieved = >0, only lines with this value will be retrieved
JSYM	JSYM	JSYM		The location of the symbol in the symbol table
LINEID	LSEQ	LSEQ		Line identifier of line currently being processed
	IRANK	IRANK		Rank and/or class of line currently being processed
LINEMD	LINEMD	LINEMD		Line mode control parameter in the General Plot Package
	PLINMD(6)	PLINMD		Parameters for the various line modes

Block Common	Fortran Variable	Math Symbol	Units	Description
LINMDE	LINMDE	LINMDE		Line mode control parameter
	VLINMD(6)	VLINMD		Parameters for the various line modes
LOOKCM	IENTRY	IENTRY		Number of entries in LR table
	LR(250)	LR		Pointers to X, Y values for area fill
MAIN1	ICOLIN	ICOLIN		Line control parameter 0, no line data >0, format type of data to be processed See CAM user's guide
	IOVRLY	IOVRLY		Overlay control parameters 0, no line data >0, indicates which overlay feature to be drawn See CAM user's guide
	ISYMPT	ISYMPT		Symbol control parameter 0, no symbol plot >0, format type of data to be processed See CAM user's guide
MAP	MAP	MAP		Map projection control parameter. See MAP under DUM1 array for further description.
MAP4	CPIP4			Not used
NPP	NPP	NPP		Previous value of plotter pen or aperture
NTYPE	NTYPE	NTYPE		Control parameter for dashed lines
NWRD				not used
ORHALT	ORHALT	PER_{ALT}	Nautical Miles	The altitude of the light source for the perspective projection
ORHCON	ORHC1	P_{c1}	Nautical Miles^2	$r^2 + (r + PER_{ALT})^2$
	ORHC2	P_{c2}	Nautical Miles^2	$2 \cdot r \cdot (r + PER_{ALT})$
	ORHC3	P_{c3}	Nautical Miles^2	$2 \cdot r \cdot PER_{ALT}$
	ERMAX	ER_{MAX}	Radians	The earth central angle from the line center of earth to light source to the line center of earth to the horizon
PIE	PIE	π	3.1415927	π
PIO2	PIO2	$\pi/2$	1.5707963	$\pi/2$
PIO4	PIO4	$\pi/4$	.7853982	$\pi/4$
PLINP	NINT	NINT	7	Data set reference number for CAM input cards
	INPT	INPT	—	Control parameter for initializing parameters in POLINP
	ITIME	ITIME	—	Previous value of TIME

Block Common	Fortran Variable	Math Symbol	Units	Description
POINTA	RHOA	ρ_A	Radians	Latitude of Point A
	XMUA	μ_A	Radians	Longitude of Point A
	RHOB	ρ_B	Radians	Latitude of Point B
	XMUB	μ_B	Radians	Longitude of Point B
	SXA	X_A	Inches	X distance from map origin to Point A
	SYA	Y_A	Inches	Y distance from map origin to Point A
	SXB	X_B	Inches	X distance from map origin to Point B
	SYB	Y_B	Inches	Y distance from map origin to Point B
PLY	E2	E^2		All of these parameters are transformation constants for the Polyconic Projection
	FA	A^1		
	FB	B^1		
	FC	C^1		
	FD	D^1		
	FE	E^1		
	AN	N		
	AN2	N^2		
	AN3	N^3		
	AN4	N^4		
	AN5	N^5		
PTOL	PTOL	PTOL	Inches	Minimum distance between consecutive points on the plot
RADE	RADE	a	Nautical Miles	Radius of the earth
RADEG	RADEG	RADEG	57.2957795	Radian to degree conversion factor
RANMAX	RANMAX	r_{max}	Nautical Miles	Radius of Azimuthal Equidistant, Lambert Azimuthal Equal Area, or Stereographic Projections
RRING	RRAZD	RR_{AZ}	Radians	Angular increment used to generate circles, ellipses or range rings
	RR	RR	—	Radius of range rings or ellipses in nautical miles; or angle in degrees for area fills
	TICKAZ	T_{AZ}	Radians	Control parameter for tick marks on the range ring or circle = 0, no tick marks = >0, tick marks will be drawn every TICKAZ radians
	TLENG	T_L	—	Length of tick mark in inches on the range ring or circle; or the area fill option
RRING1	RRMAX	RR_{max}	—	• Radius in nautical miles of last range ring, or • Semi-major axis of ellipse in nautical miles, or • Format type for input to area fill

Block Common	Fortran Variable	Math Symbol	Units	Description
	DELRR	ΔRR		• Range rings are drawn every DELRR nautical miles, or • Nautical mile increment used to generate points in the sides of a "range box," or • Semi-minor axis of ellipse in nautical miles • Distance in inches between lines in area fill, or • Nautical mile increment used to generate points in great circle paths
SCALI	TSLAT	ρ_1	Radians	True scale latitude
	SADEMR	S		Map scale
	CONFAC	C_1		Conversion factor. The number of inches in a nautical mile 72960; or, the number of inches in a meter 39.37.
	ICALIB	ICALIB		Map scale calibration control parameter =0, no calibration =1, map scale is calibrated by two points from the map
SCRIBE	ISCRIB	ISCRIB		Control Parameter =0, positive plot image =1, negative plot image
SORL	ISORL	ISORL		Control parameter for drawing symbols =0, program uses plotter manufacturer's software to generate symbol =1, draws the symbol by the standard symbol generator software =2, flashes the symbol =3, selects the symbol from the symbol table
STDPAR	RHOSP1	ρ_{SP1}	Radians	Latitude of lower standard parallel
	RHOSP2	ρ_{SP2}	Radians	Latitude of upper standard parallel
	ILK	ILK		Control parameter for the calculation of ℓ and k
	NSDIR	NSDIR	0 or 1	Control parameter for Lambert Projection
TAPES	NTAP	NTAP	—	Data set reference number for plotter output
	NDAT	NDAT	—	Data set reference number for data to be symbol plotted
	NDAT2	NDAT2	—	Data set reference number for data to be line plotted
TEMPDS	NPS	NP	—	Number of total points generated in Corridor option
	IBS	IB	—	Number of points saved in RHOST and XMUST
	RHOST(100)	ρ	—	Array of latitude points for write to temporary space

Block Common	Fortran Variable	Math Symbol	Units	Description
	XMUST(100)	μ_{ST}		Array of longitude points for write to temporary space
TMS	EPRIM2	E'^2		Minor eccentricity squared
	E2	E^2		Major eccentricity squared
	FA	A'		Constant for the Transverse Mercator Spheroid (UTM) Projections
	FB	B'		Constant for the Transverse Mercator Spheroid (UTM) Projections
	FC	C'		Constant for the Transverse Mercator Spheroid (UTM) Projections
	FD	D'		Constant for the Transverse Mercator Spheroid (UTM) Projections
	FE	E'		Constant for the Transverse Mercator Spheroid (UTM) Projections
	AN	N		Constant for the Transverse Mercator Spheroid (UTM) Projections
	AN2	N^2		Constant for the Transverse Mercator Spheroid (UTM) Projections
	AN3	N^3		Constant for the Transverse Mercator Spheroid (UTM) Projections
	AN4	N^4		Constant for the Transverse Mercator Spheroid (UTM) Projections
	AN5	N^5		Constant for the Transverse Mercator Spheroid (UTM) Projections
	ZKO	ZK_0		Constant which causes the scale to be true on the CM if equal to one. If less than one, scale is true on either side of CM.
TPIE	TPIE	2π	6.2831853	$2 \cdot \pi$
TPLOT	TPLOT	TPLOT		Not used
TSTOR	DUM1(160)	DUM1	--	Array for storing input values
	SAVE(160)	SAVE		Another array for storing input values
UTM	A	A	Meters	Semi-major axis of spheroid
	B	B	Meters	Semi-major axis of spheroid
	CM	CM	Radians	Central Meridian
UTM2	CMD	CMD	Degrees	Central Meridian – degree part
	CMM	CMM	Minutes	Central Meridian – minute part
	CMS	CMS	Seconds	Central Meridian – second part
XSYS	XS	X_s	----	The X scale factor
	YS	Y_s		The Y scale factor
XYLIM	XLIM	XLIM	Inches	Distance from plot center to right margin
	YLIM	YLIM	Inches	Distance from plot center to top margin
	RHOLOW	ρ_{LOW}	Radians	Latitude of lower map boundary
	RHOUP	ρ_{UP}	Radians	Latitude of upper map boundary
	XMULFT	μ_{LFT}	Radians	Longitude of left boundary
	XMURGT	μ_{RGT}	Radians	Longitude of right boundary
XYOFF	XOFF	XOFF	Inches	X-origin offset
	YOFF	YOFF	Inches	Y-origin offset

VII. DESCRIPTION OF SELECTED SUBROUTINES AND OVERALL FLOW CHART

A. Subroutine COREAD

Purpose: To call the proper subroutine to read data to be line plotted.

Calling Sequence:
Call COREAD (N, K, ρ, μ, KOUNT)

N	data set reference number of input device where data is located
K	$=5$, end of data $\neq 5$, not the end of data
ρ	The latitude of point to be plotted $=95$, the end of a line segment
μ	The longitude of point to be plotted
KOUNT	The number of values in the ρ and μ arrays KOUNT ≤ 50

Common Blocks
MAIN1

B. Subroutine COTRAF

Purpose: To call the proper co-ordinate transformation (from latitude/longitude to unscaled X/Y) subroutine for a given projection.

Calling Sequence:
Call COTRAF ($\Delta\mu$, ρ, X, Y)

$\Delta\mu$ — the longitude reference from the origin $= \mu - \mu_0$
ρ — the latitude
X — the unscaled X-distance
Y — the unscaled y-distance

Common Blocks
MAP

C. Subroutine CSCALE

Purpose: (1) To compute or determine the scale from the initial inputs
(2) To compute the necessary constants for a given projection

Calling Sequence:
Call CSCALE
All input parameters and output parameters are in common
Common Blocks
MAP

D. Subroutine GRATIC

Purpose: (1) Check for $\Delta\mu$, ρ within map boundary
(2) Transformation of co-ordinates and scaling
(3) Shift X and Y
(4) Check for X, Y within plotter board limits
(5) Check for X, Y within open box
(6) Draw line

Calling Sequence:
Call GRATIC ($\Delta\mu$, ρ)
$\Delta\mu$—reference longitude $\Delta\mu = \mu - \mu_0$
ρ —latitude

Approved For Release 2000/09/14 : CIA-RDP86T00608R000600100004-2

Common Blocks:
BOXLIM
CETPOT
DISAZ
ISWAT
MAP
PIE
RANMAX
TAPES
TPIE
XSYS
XYLIM
XYOFF

E. Subroutine OVRLAY

Purpose: To call the proper subroutines to do the following:
1. Draw a latitude longitude line grid
2. Draw range rings
3. Draw a circle
4. Draw azimuth lines and elevation rings
5. Draw a box
6. Draw an ellipse
7. Draw a great circle path between two points
8. To fill an area with lines, symbols, or cross-hatches
9. Rectangular box
10. Not used
11. UTM line grid
12. Latitude/longitude tick grid
13. UTM tick grid
14. Corridor

Calling Sequence:
Call OVRLAY

Common Blocks:
MAIN1

F. Subroutine RYTOUT

Purpose: To call subroutines to write a variety of plotter commands on tape.
Calling Sequence:
Call RYTOUT (N,X,Y,KODE)
N — Data set reference number of the plotter output tape
X — The X co-ordinate of the point in inches
Y — The Y co-ordinate of the point in inches
KODE — Indicates which plotter command
=1, To draw a line from the previous point or to plot symbols, depending on the plotter mode
=2, To set the scale factor
=3, To clear the plotter
=4, To clear the plotter
=5, To set-up the symbol(s) to be plotted. X is the number of symbols to be plotted. Y is the dimensioned array containing the Alpha-numeric symbols to be plotted.

6, Set the pen to the line mode
7, Not used
8, Pen up command
9, Pen up and move pen to origin
10, Draws corner ticks at X/2 and Y/2 from the origin
11, Clears plot buffer and writes end of file on tape

Common Blocks:
TPLOT
PTOL
ICTPIN
SORL
SCRIBE

G. Subroutine TGTRED

Purpose: To read co-ordinates and symbols to be printed or drawn

Calling Sequence:

Call TGTRED (N_r,k,φ,μ,K_{sym},SYMB)

N_r	Data set reference number of input data
K	Control parameter for end of data $\neq 5$, data 5, end of data
φ	Latitude
μ	Longitude
K_{sym}	The number of characters to be plotted
SYMB	Dimension array containing the symbols to be plotted

Common Blocks:
MAIN1

CAM FLOW CHART

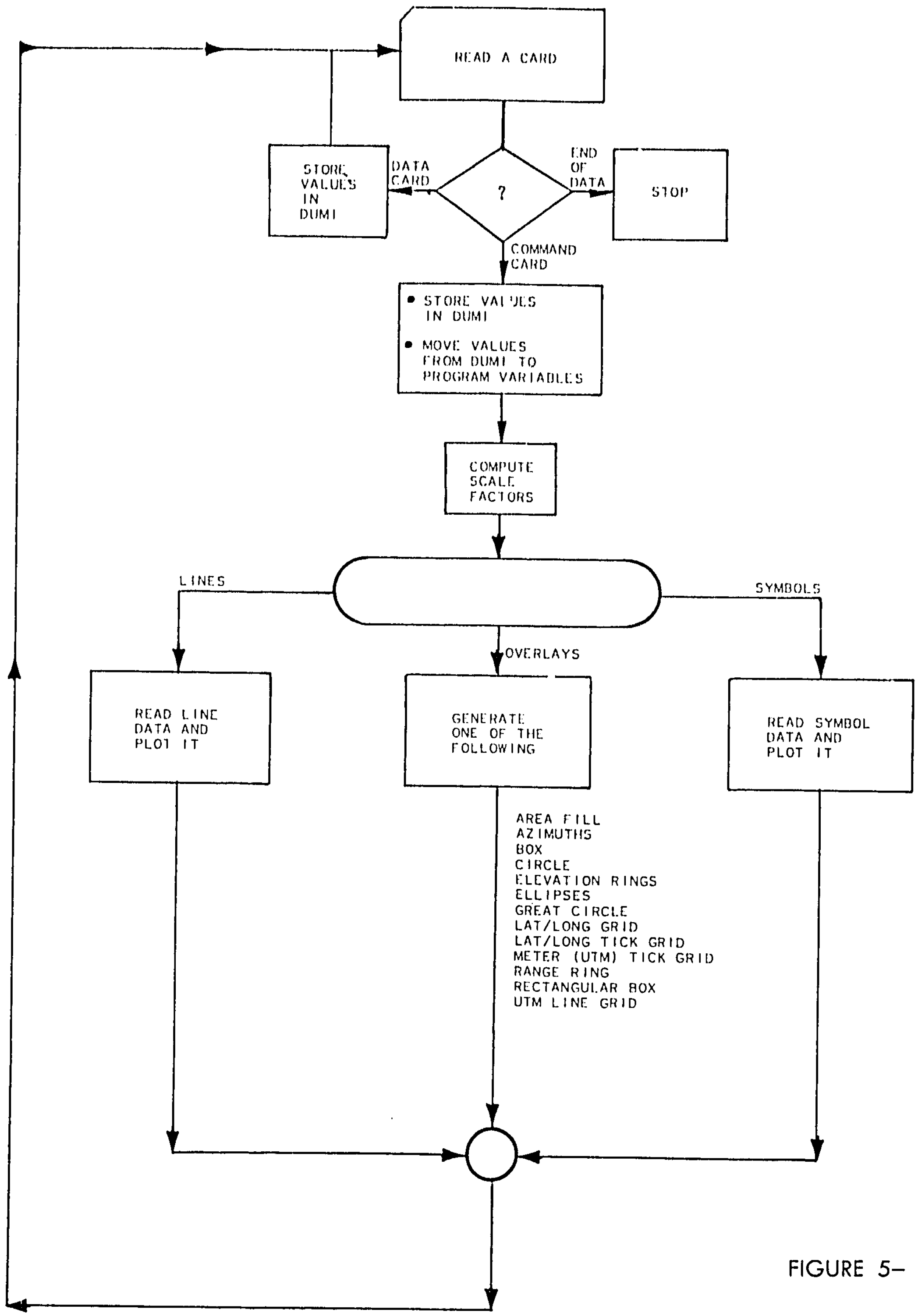

FIGURE 5–

VIII. GLOSSARY OF SUBROUTINES

A. FORTRAN Subroutines

ARCOS	Computes the angle, given the cosine
ATAN2	Computes the angle whose tan is Y X. Range of the angle is ± 180.
AZED	Transformation from latitude, longitude to X-Y for the Azimuthal Equidistant Projection
AZESAL	Computes the scale factors for the Azimuthal Equal-Area Projection
AZSCAL	Computes the scale factors for the Azimuthal Equidistant Projection
BLCOMP	This routine interfaces with the General Plotting Package subroutine. Both symbols and line data are passed.
BODE	Draws elevation rings and/or azimuths. It will also put tick marks on the azimuths.
BOX	Draws a rectangle around a given point. Its length and width are given in inches.
CALC	Calculates the intersection of a horizontal line with a line
CARDIN	Reads the 80 character input card, stores it, and writes it on SYSOUT
CEAGEN	Computes the transformation constants for the Albers Projection
CEIKA4	Computes the constant of the cone and the integration constant for the Kavraiskiy IV Projection
CEISP1	Computes the constant of the cone and the integration constant for the Ptolemy Projection
CIRCLE	Draws a circle around a given latitude-longitude point with constant radius in inches
CIRINT	Computes intersection of two great circles
CKWISE	Determines the direction of a line
CONCON	Transformation from latitude-longitude to X-Y for Lambert Projection
CONEAR	Transformation from latitude-longitude to X-Y for Albers Projection
CONEIN	Transformation from latitude-longitude to X-Y for Kavraiskiy IV and Ptolemy Projections
CONINT	Calls the proper subroutine to compute the transformation constants (l, k, r_o) for a given conic projection
CONSAL	Computes the scale factors for conic projections
COREAD	Calls the proper subroutine to read data to be line or symbol plotted
CORRID	Draws corridor—main or either side
CORTIK	Draws corner ticks
COTRAF	Calls the proper transformation subroutine to go from latitude-longitude to X-Y for a given projection
CSCALE	Calls the proper subroutine(s) to compute the scale factors and transformation constants
DAHLGN	To read coastline data in the Dahlgren format
DARCOS	Determines the angle whose cosine is given in double precision
DISTAZ	Computes the shortest distance between two points and its angle from North

ELRING	Draws an ellipse around a given latitude, longitude
ENDPOT	Computes the end point; given the first point, distance, and azimuth
GNOXY	Transformation from latitude, longitude to X-Y for the Gnomonic Projection
GRASYM	Draws a symbol(s) at a given latitude, longitude
GRATIC	Checks for latitude, longitude point with map boundaries, projection limits, and plotter limits. Then it draws the line.
GRDLIN	Draws a line grid within specified boundaries
GRTCIR	Draws a great circle path between points
GUMSCL	Computes transformation constants for the UTM line and tick grids
GUTMLL	Converts UTM meters to latitude/longitude for the UTM line and tick grids
INOUT	Determines whether a point is inside or outside a polygon
INPUTS	Moves input values from DUM1 array to actual FORTRAN parameters
LAMINT	Computes the transformation constants for the Lambert Projection with two Standard Parallels
LAZEQA	Transformation from latitude, longitude to X-Y for the Azimuthal Equal-Area Projection
LNPOT	Control subroutine to read data to be line plotted and pass it to subroutine GRATIC
LLTKGD	Draws ticks along latitude/longitude grid
LOOK	Locates an index in an array for area fill
LTRACI	Reads latitudes, longitudes in the TRACE I format
MAIN	Controlling routine for the flow of the program
MBFMT	Reads latitudes, longitudes, and symbols in the MBFMT format
MERCAL	Computes the scale factors for the Mercator, Miller Cylindrical and Transverse Mercator Projections
MERCAT	Transformation from latitude, longitude to X-Y for the Mercator Projection
MILCYL	Transformation from latitude, longitude to X-Y for the Miller Cylindrical Projection
MTKGRD	Draws ticks along UTM grid
NEWPLT	Controls the drawing of corner ticks, center ticks, and registry lines. It endfiles plot tape and initializes the plotter software.
ONOPOT	Transformation for the X-Y Display
ONORED	Reads data in the Graphic Data Format
ONOSAL	Computes the scale factors for the X-Y Display
ORTHO	Transformation from latitude, longitude to X-Y for the Orthographic Projection
ORTSAL	Computes the scale factors for the Orthographic Projection
OVRLAY	Calls the proper subroutine for overlay features - line grid, range rings, circles, etc.
PERSAL	Computes the scale factors for the Perspective Projection
PERSP	Transformation from latitude, longitude to X-Y for the Perspective Projection
PITPOT	Calls subroutine TGTSYM
POLINP	Stores input values in the DUM1 and SAVE arrays
POLSAL	Computes scale factors for Polyconic Projection
POLY	Transformation from latitude/longitude to X-Y for Polyconic Projection

POSCAL	Computes the scale factors for the Stereographic Projection
POSTER	Transformation from latitude, longitude to X-Y for the Stereographic Projection
PSETUP	Makes necessary calls to initialize and clear plotter software
RANBOX	Draws a rectangle whose length and width are given in nautical miles
RARING	Draws range rings centered at a given latitude, longitude point. It will also draw tick marks on the range rings.
RDATAB	Reads latitudes, longitudes in the 80 character World Data Bank I Format (radians)
RDATAD	Reads latitudes, longitudes in the 80 character World Data Bank I Format (degrees, minutes, seconds)
RDATAR	Reads latitudes, longitudes in the Eight Byte World Data Bank II Format
RDATBB	Reads latitude, longitudes in World Data Bank I Format (three data points per second)
RDXYZ	Reads latitudes, longitudes, and elevations in the format (12X, F7.3, F10.3, F12.2)
RECSAL	Computes the scale factors for the Equirectangular Projection
RECTAN	Transformation from latitude, longitude to X-Y for the Equirectangular Projection
REGMAP	Draws registry lines
RYTOUT	Interface between program and the BLCOMP subroutine
SAVIT	Used to store data and write to temporary data set
SINEQA	Transformation from latitude, longitude to X-Y for the Sinusoidal Projection
SOLARE	Reads latitudes, longitudes of a polygon, transforms to X-Y, and passes to SOLFIL subroutine
SOLFIL	Fills an area with lines, symbols or crosshatching
STRINT	Finds the intersection of two straight lines
TGTRED	Controls the reading of data to be symbol plotted
TGTSYM	Controls the plotting of symbol data
TMERCT	Transformation from latitude, longitude to X-Y for the Transverse Mercator Projection
TMSCAL	Computes the scale factors and other constants for the Universal Transverse Mercator Projection
TRACSY	Reads latitude, longitude in the TRACE I format for symbol plotting. A dot (.) is drawn at each point.
UTMGRD	Draws line along standard UTM grid
UTMXY	Transformation from latitude, longitude to X-Y for the Universal Transverse Mercator Projection
WDBIN	Reads latitudes, longitudes in the Twenty-Two (22) Byte Binary World Data Bank Format

B. Assembly Language Subroutines

ADATA	Processes a character string containing a name and one or more numeric constants. It returns the name as a character string and the constants as single precision real constants.
ALFIE	Converts a character string (A-format) to single or double precision floating point
CLOCK	Returns current time
FILDEF	Duplicates the Fortran DEFINE FILE statement

HOLLER Converts an integer to a character string
INCORE Converts from binary to character string or from character string to binary according to D, E, F, G, I, L, and Z formats

C. General Plotting Subroutines

The subroutines described here interface with the software that generates the required plotter commands for the Gerber and Calcomp plotters, or graphic data format. A debug option is available which lists the values of the parameters in the calling sequence of each subroutine.

PLINIT Initializes the parameters for whichever plotter was selected
FLASH Will draw the symbol requested for all plotters except the Gerber. The Gerber flashes light through the requested aperture position.
LETTER Draws characters, numbers, and special characters. The lower left hand corner of the first symbol is at (X-Y).
LINMOD Selects the line mode
MVPEN Moves the pen or light source to a specified location
SPRINT Draws characters centered on a specified X-Y location
TYPMSG Writes alpha-numeric characters on the plot tape as messages to the plotter operator via the teletypewriter at the plotter

D. Subroutines for Line Modes

CANAL Draws the canal symbol ( )
DASHI Draws various dash lines
DASHLN Draws dash line ( )
MOVPEN Called by MVPEN to interface with the requested line mode subroutine
MOVPEN Called by MVPEN
NARGAG Draws narrow gauge railroad symbol ( )
REEFSY Draws a saw-toothed line for reefs
RRMULT Draws multi-rail railroad symbol ( )
RRTICK Draws standard gauge railroad symbol ( )

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IX. MAP PROJECTIONS — DESCRIPTION AND SAMPLES

This chapter is intended to give the user a better understanding of the various map projections available within CAM. Each one is described and a sample map is provided along with the input data set used to generate it. For purposes of quick comparison, Figure 6 illustrates the properties, coverage, and applications of the individual projections.

	PROPERTIES					AREA						APPLICATION			
	Conformal	Equal-Area	Equidistant	Azimuthal	Compromise	World	Hemisphere	Continent Ocean	Region Sea	Medium-Scale	Large-Scale	Presentation	Topographic	Navigation	Area Measurement
Albers		•							•	•		•			•
Azimuthal Equal-Area		•		•		•	•	•				•			•
Azimuthal Equidistant			•	•		•	•	•				•			
Equirectangular					•	•	•	•	•	•	•	•			
Gnomonic				•				•	•					•	
Kavraiskiy IV					•			•	•			•			
Lambert CC	•							•	•	•	•	•		•	
Mercator	•					•	•	•				•		•	
Miller					•	•						•			
Orthographic				•			•	•	•			•			
Perspective				•			•	•	•			•			
Polyconic					•						•		•		
Ptolemy					•				•			•			
Sinosoidal		•				•	•	•				•			•
Stereographic	•			•			•	•	•		•		•	•	
Transverse Mercator	•						•				•	•	•		

Definitions:

Conformal Angles and shapes of all figures within small areas are true.

Equidistant All distances in any direction from a given point are in proportion.

Azimuthal—All azimuths from the center are true and straight lines through the center are great circles.

Compromise Projections with small angular, areal or linear scale distortion.

Medium-scale 1:100,000 to 1:1,000,000

Large-scale Larger than 1:100,000

Presentation Reference, educational and planning maps.

Figure 6 Guide To CAM Projections

A. AZIMUTHAL PROJECTIONS

The Azimuthal family is a versatile class of map projections. By varying the scale along the great circles radiating from the map center, useful characteristics can be achieved, such as equal distance from the center (Azimuthal Equidistant), equivalence (Azimuthal Equal-Area), conformality (Stereographic), appearance of viewing from space (Orthographic and Perspective), and great circles anywhere on the map represented by straight lines (Gnomonic). Common features of azimuthal projections are correct azimuths to and from the center (which can be located anywhere) and symmetrical deformation.

Approved For Release 2000/09/14 : CIA-RDP86T00608R000600100004-2

AZIMUTHAL EQUAL—AREA

This projection, invented by Lambert, is best suited to small-scale maps of continental areas or hemispheres. The equivalent property is especially valuable for depicting distributions or measuring defined areas. Figure 7 is centered on Kinshasa, 4°28'S., 15°16'E., to illustrate the value of this projection in mapping areas that extend considerable distances in all directions. The azimuths from the center point show two characteristics common to all azimuthal projections—all azimuths are correct from the center and straight lines through the center point are great circles.

```
PLOTTER  14.,2.,.01,10.,1.,8.,.4.
AZEQAREA  5400.
CETPOT  -4.,25.,,16.,25.
MAPBOUND  -90.,,,90.,,,-180.,,,180.
MAPSAL  2.81
XYLIM  5.5,7.
SAVE
XYLIM  4.25,5.5
SAVE
2     11 x 14 ONE PLATE COMPOSITE
EOF
1     AZIMUTHAL EQUAL  AREA
-2.81            -3.25
2     GRID
LGRID  20.,20.,.25,.25,-80.,,,80.,,,-180.,,,180.
2     CIRCLE
PLOTTER  14.,8.,.01,10.,1.,8.,.4.
SAVE
CIRCLE  -4.,25.,,16.,25.,,2.81,1.
2     COAST
PLOTTER  14.,3.,.01,10.,1.,8.,.4.
SAVE
LINEPT  8.,2.
2     BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,.4.
SAVE
LINEPT  11.,2.
2     AZIMUTHS
PLOTTER  14.,4.,.01,10.,1.,8.,.4.
SAVE
BODE  -4.,25.,,16.,25.,,20.,5400.,20.,90.,,0.,90.,90.,0.,90.,0.,90.,45.,315.
2     CORNER TICKS
PLOTTER  14.,1.,.01,10.,1.,8.,.4.
SAVE
CORNERTK
SPLATE
```

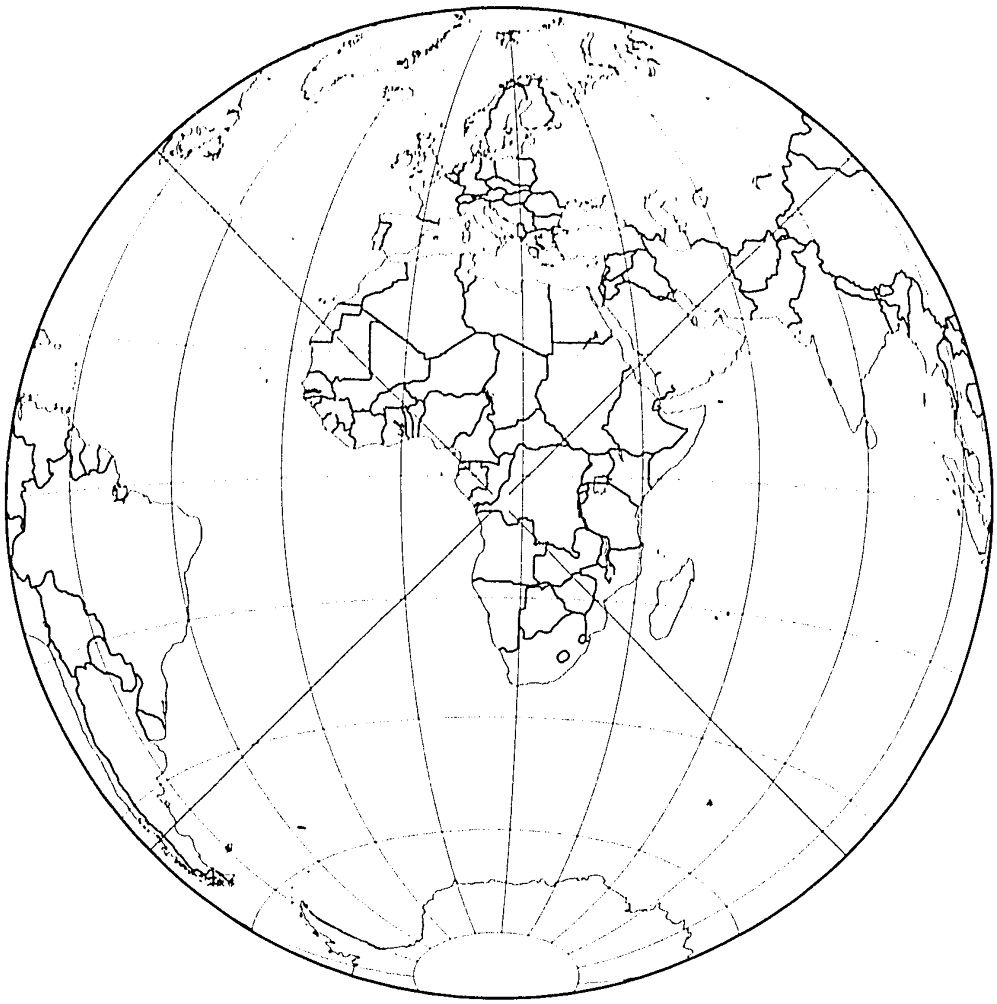

Figure 7. AZIMUTHAL EQUAL-AREA

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AZIMUTHAL EQUIDISTANT

The Azimuthal Equidistant projection is employed where the distance and azimuth are required from a central point to any other point. A hemisphere or even the entire earth around one radio station is a popular application. Figure 8 is an example of a map that could be used to measure distances and azimuths from Washington, D.C. to any place in the world.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
AZED  10800.
CETPOT  38.,56.,,-77.,2.
MAPBOUND  -90.,,,90.,,,-180.,,,180.
MAPSAL  2.81
XYLIM  5.5,7.
SAVE
XYLIM  4.25,5.5
SAVE
2     11 x 14 2 PLATES
2     PLATE 2 USE SCREEN 50
EOF
1     AZIMUTHAL EQUIDISTANT
-2.81           -3.25
2     GRID
LGRID  30.,30.,.25,.25,-80.,,,80.,,,-180.,,,180.
2     CIRCLE
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
CIRCLE  38.,56.,,-77.,2.,,2.81,1.,10.,.1
2     COAST
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2     BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2     RANGE RINGS PLATE 2 SCREEN 50
PLOTTER  14.,4.,.01,10.,1.,8.,,4.
SAVE
RRANGE  38.,56.,,-77.,2.,,0.,360.,1.,1000.,5000.,1000.
2     CORNER AND CENTER TICKS
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CORNERTK
CENTERTK
SPLATE
```

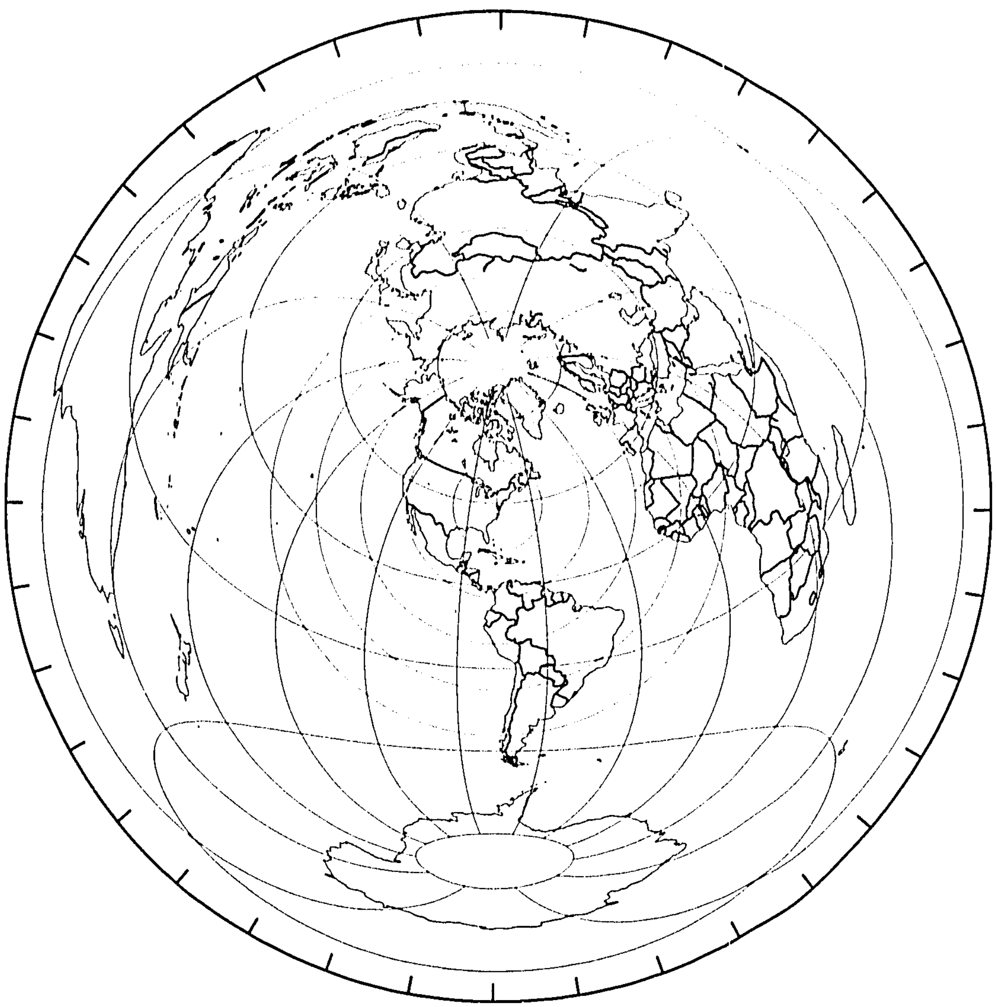


Figure 8. AZIMUTHAL EQUIDISTANT

GNOMONIC

The unique property of this projection is that any straight line on the map represents a great circle trace. Its application is restricted to the depiction of great circles over long distances for navigational purposes. It is best suited to areas not exceeding 40° of longitude from the central meridian. The straight line between Halifax and San Francisco in Figure 9 is a great circle route.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
GNOMONIC
MAPBOUND  10.,,,70.,,,-140.,,,-50.
CETPOT  41.,,,-95.
MAPSAL  35000000.
XYLIM  5.5,7.
SAVE
XYLIM  3.18,2.5
SAVE
2     11 x 14
2     ONE PLATE COMPOSITE
EOF
1     GNOMONIC
-3.18          -3
2     GRID
LGRID  10.,10.,.25.,25,10.,,,70.,,,-140.,,,-50.
2     BOX
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
BOX  41.,,,-93.,,,3.18,2.5
2     COAST
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2     BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2     GREAT CIRCLE
PLOTTER  14.,5.,.01,10.,1.,8.,,4.
SAVE
GTCIRCLE  50.,7.
100001               HALIFAX                         444000N0633600W
100001               SAN FRANCISCO                   374500N1222600W
9
9
SPLATE
2     CENTER TICK
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CENTERTK
SPLATE
```

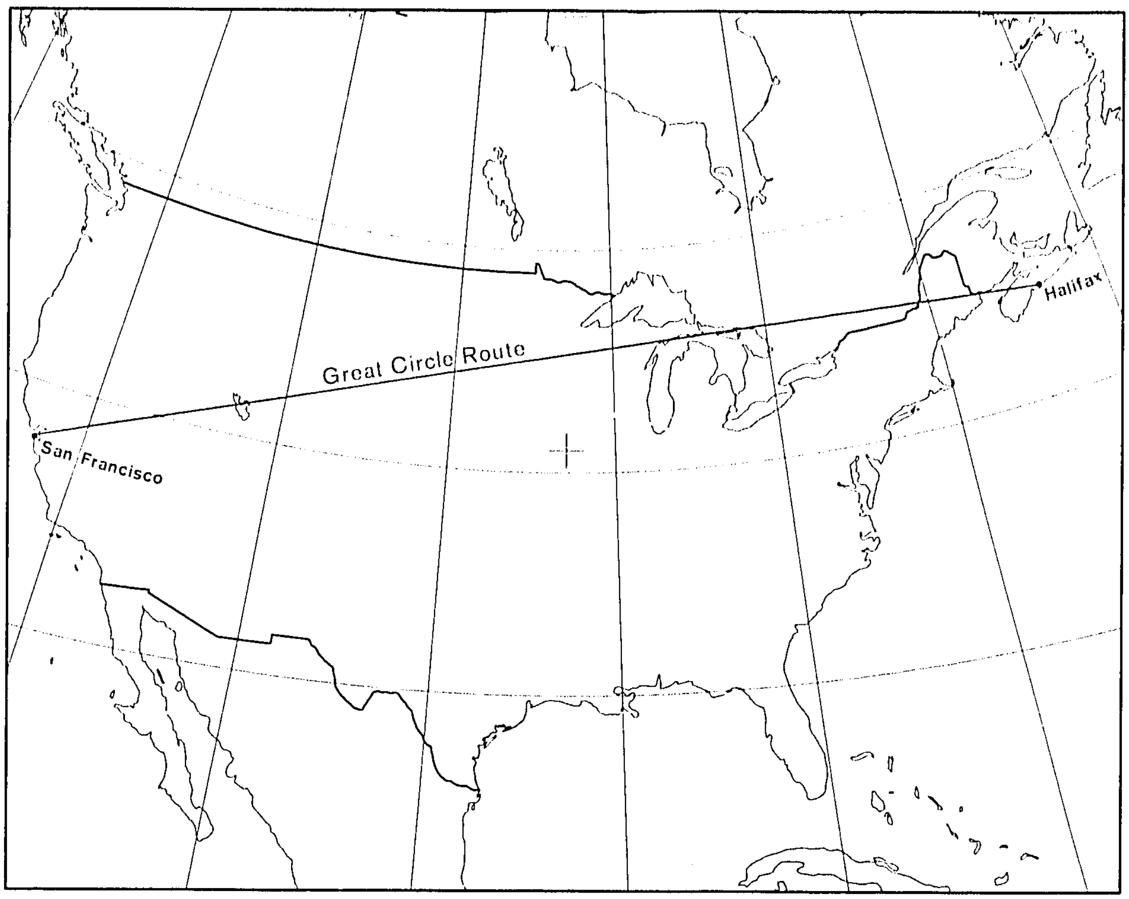


Figure 9. GNOMONIC

ORTHOGRAPHIC

The perspective quality of this projection makes it useful for presenting hemispheres centered on any point on the globe. The result is a realistic spherical appearance as if viewed from deep space. It differs from the Perspective in that its focus is from infinity. Compare Figure 10, centered on Washington, D.C., Projection with Figure 11.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
ORTHO
CETPOT  38.,56.,,-77.,2.
MAPBOUND  -90.,,,90.,,,-180.,,,180.
MAPSAL  2.81
XYLIM  5.5,7.
SAVE
XYLIM  4.25,5.5
SAVE
2    11 x 14   1 PLATE COMPOSITE
EOF
1    ORTHOGRAPHIC
-2.81              -3.25
2    GRID
LGRID  30.,10.,.25,.25,-80.,,,80.,,,-180.,,,180.
2    CIRCLE
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
CIRCLE  38.,56.,,-77.,2.,,2.81,1.
2    COAST
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2    BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2    RANGE RINGS
PLOTTER  14.,4.,.01,10.,1.,8.,,4.
SAVE
RRANGE  38.,56.,,-77.,2.,,0.,360.,1.,1000.,5000.,1000.
2    CORNER AND CENTER RICKS
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CORNERTK
CENTERTK
SPLATE
```

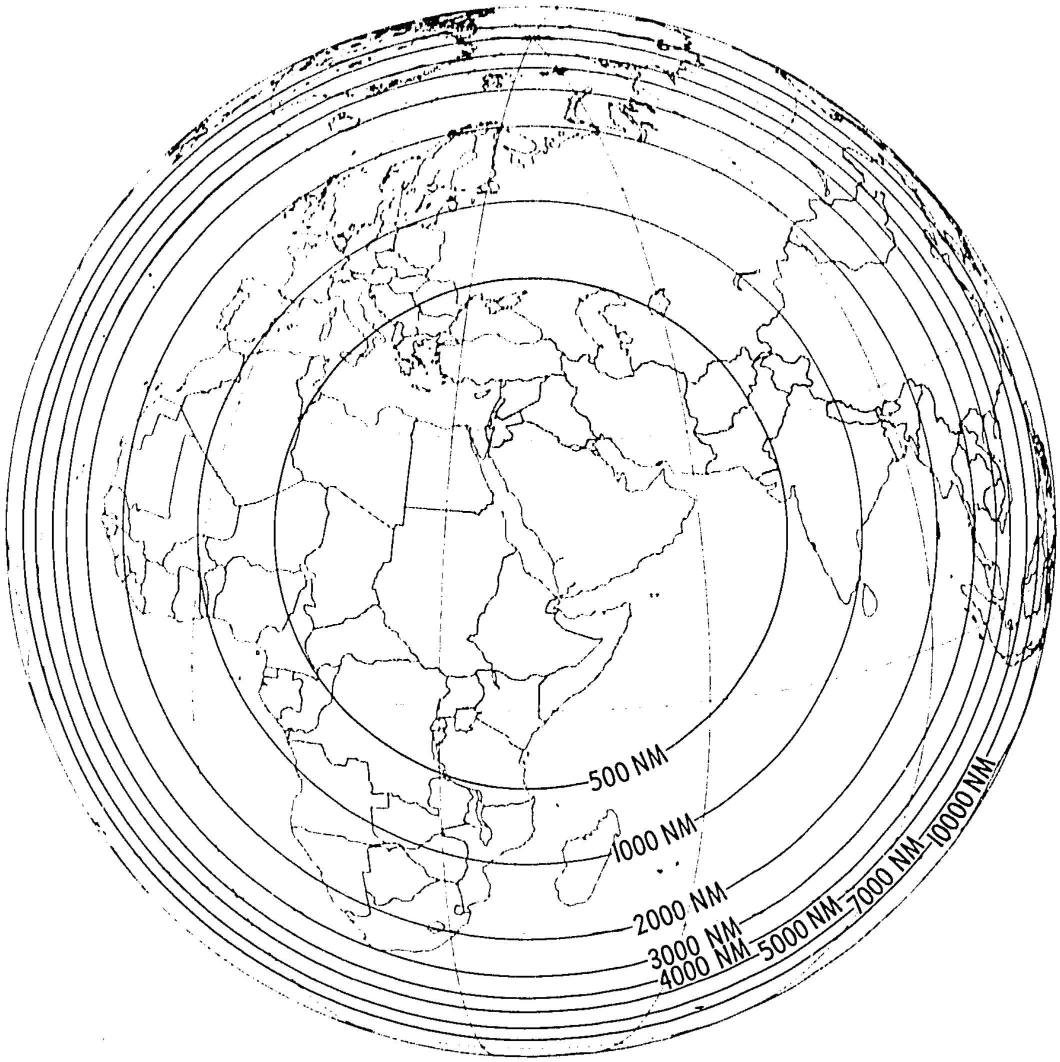
Figure 10. ORTHOGRAPHIC

PERSPECTIVE

Unlike the Orthographic with the "observer" at infinity, the Perspective focus is from a point in near rather than deep space. The spherical illusion of viewing from a high satellite is retained even when only a portion of the globe is shown. Its primary use is for orientation with the map centered on the area of interest. In addition to use for limited small-scale coverage, areas less than a hemisphere can be shown. Figure 11 is centered over Washington, D.C., with the "viewer" at an altitude of 5,000 nautical miles. Figure 12, plotted on the Orthographic, can be used to plan Perspective map coverage.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
PERSP  5000.
CETPOT  38.,56.,,-77.,2.
MAPBOUND  -90.,,,90.,,,-180.,,,180.
MAPSAL  2.81
XYLIM  5.5,7.
SAVE
XYLIM  4.25,5.5
SAVE
2    11 x 14 ONE PLATE COMPOSITE
EOF
1    PERSPECTIVE
-2.81              -3.25
2    GRID
LGRID  30.,10.,.25,.25,-80.,,,80.,,,-180.,,,180.
2    CIRCLE
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
CIRCLE  38.,56.,,-77.,2.,,2.81,1.
2    COAST
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2    BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2    RANGE RINGS
PLOTTER  14.,4.,.01,10.,1.,8.,,4.
SAVE
RRANGE  38.,56.,,-77.,2.,,0.,360.,1.,1000.,5000.,1000.
2    CORNER AND CENTER TICKS
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CORNERTK
CENTERTK
SPLATE
```

Figure 11. PERSPECTIVE



Coverage of the Earth Perspective Projection at Various Altitudes (NM)
(Plotted on the Orthographic)

Altitude	Theoretical Coverage	Effective Coverage
100NM	819NM	515NM
200	1145	722
500	1751	1112
1000	2353	1511
2000	3047	1988
3000	3463	2287
4000	3748	2497
5000	3957	2655
7000	4245	2879
10000	4510	3090

Figure 12. PERSPECTIVE GUIDE ON ORTHOGRAPHIC

STEREOGRAPHIC

This is the conformal member in the Azimuthal family and the only projection on which any circle on the earth is projected as a circle on the map. This feature permits the user to plot with a compass such things as aircraft, radar, and radio ranges. However, the major application is the depiction of polar areas for topographic maps and navigation charts. The circles drawn around selected capital cities in the Oblique Case in Figure 13 are 500 nautical mile range rings.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
STEREO  0.,,,5400.
CETPOT  1.,17.,,103.,51.
MAPBOUND  -90.,,,90.,,,-180.,,,180.
MAPSAL  2.5
XYLIM  5.5,7.
SAVE
XYLIM  4.25,5.5
SAVE
XYOFF  .8,-1.3
SAVE
2    11 x 14 ONE PLATE COMPOSITE
EOF
1    STEREOGRAPHIC
-3.          -4.
2    GRID
LGRID  20.,20.,.25,.25,-80.,,,80.,,,-180.,,,180.
2    CIRCLE
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
CIRCLE  1.,17.,,103.,51.,,2.5,1.
2    COAST
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
SPLATE
2    BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
SPLATE
2    RANGE RINGS SCREEN 70
PLOTTER  14.,4.,.01,10.,1.,8.,,4.
SAVE
RRANGE  1.,17.,,103.,51.,,0.,360.,1.,500.,500.,500.
RRANGE  14.,35.,,120.,59.,,0.,360.,1.,500.,500.,500.
RRANGE  10.,45.,,106.,40.,,0.,360.,1.,500.,500.,500.
RRANGE  16.,47.,,96.,10.,,0.,360.,1.,500.,500.,500.
RRANGE  21.,02.,,105.,51.,,0.,360.,1.,500.,500.,500.
RRANGE  -33.,52.,,151.,13.,,0.,360.,1.,500.,500.,500.
2    CITY PLOTS
PLOTTER  14.,1.,.01,10.,2.,0.,,4.,,19.
SAVE
SYMPT  2.,7.
  1+                                              011700N1035100E
  1+                                              143500N1205900E
  1+                                              104500N1064000E
  1+                                              164700N0961000E
  1+                                              210200N1055100E
  1+                                              335200S1511300E
                                                  99
                                                  99
SPLATE
2    POLAR CASE
```

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
CETPOT  90.,,,0.
MAPBOUND  0.,,,90.,,,-180.,,,180.
MAPSAL  1.
XYOFF  -1.7,2.8
SAVE
2  GRID
LGRID  30.,30.,.25,.25,0.,,,90.,,,-180.,,,180.
SPLATE
2     CIRCLE
PLOTTER  14.,8.,.01.,1.,8.,,4.
SAVE
CIRCLE  90.,,,0.,,,1.,1.
SPLATE
2     COAST
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2     BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2     CORNER TICKS
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CORNERTK
SPLATE
```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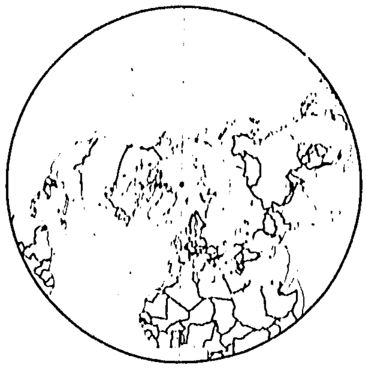

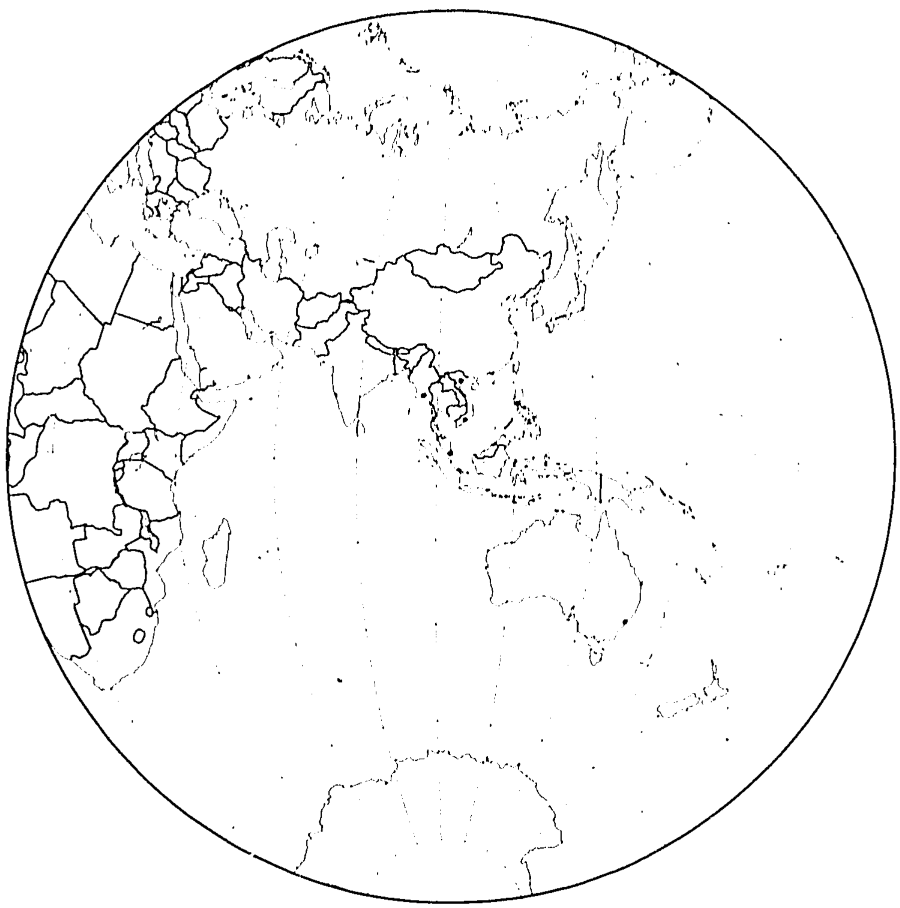

Figure 13. STEROGRAPHIC

B. CONIC PROJECTIONS

The conic group employs a cone that is either tangent to the sphere at a small circle or intersecting at two small circles. Available in CAM are the Albers, which is equal-area; the Lambert Conformal Conic, which is conformal; and two equal-interval projections, the Ptolemy and the Kavraiskiy IV.

ALBERS

This conic projection employs two standard parallels one-sixth of the distance from the top and bottom of the map. It has the valuable property of equivalency combined with minimum scale error. As such, it is especially suited for maps having a predominating east and west dimension. Maps of the United States frequently use the Albers. Figure 14, centered on 40°N., 95°W., includes five degree ticks, coastlines, boundaries, and outlining box. The standard parallels are 29°30′N. and 45°30′N.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
CEAGEN  6378388,6356912.,29.,30.,,45.,30.
MAPBOUND  10.,,,70.,,,-140.,,,-50.
CETPOT  40.,,,-95.
CONFAC  39.37
MAPSAL  35000000.
XYLIM  5.5,7.
SAVE
XYLIM  3.18,2.5
SAVE
2     11 x 14 ONE PLATE COMPOSITE
EOF
1     ALBER'S CONIC EQUAL AREA
-3.18          -3.
2     LALOTICKS
LALOTICK  10.,10.,720.,720.,10.,,,70.,,,-140.,,,-50.
2     BOX
PLOTTER  14.,8.,,01,10.,1.,8.,,4.
SAVE
BOX  40.,,,-95.,,,3.18,2.5
2     COAST
PLOTTER  14.,3.,.01,10.,8.,,4.
SAVE
LINEPT  8.,2.
SPLATE
2     BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2     RANGE RINGS AND AZIMUTHS
PLOTTER  14.,4.,.01,10.,1.,8.,,4.
SAVE
RRANGE  40.,,,-95.,,,330.,30.,1.,500.,3000.,500.
BODE  40.,,,-95.,,,500.,3000.,30.,10.,,,,,,,,,330.,30.
2     CENTER TICK
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CENTERTK
SPLATE
```

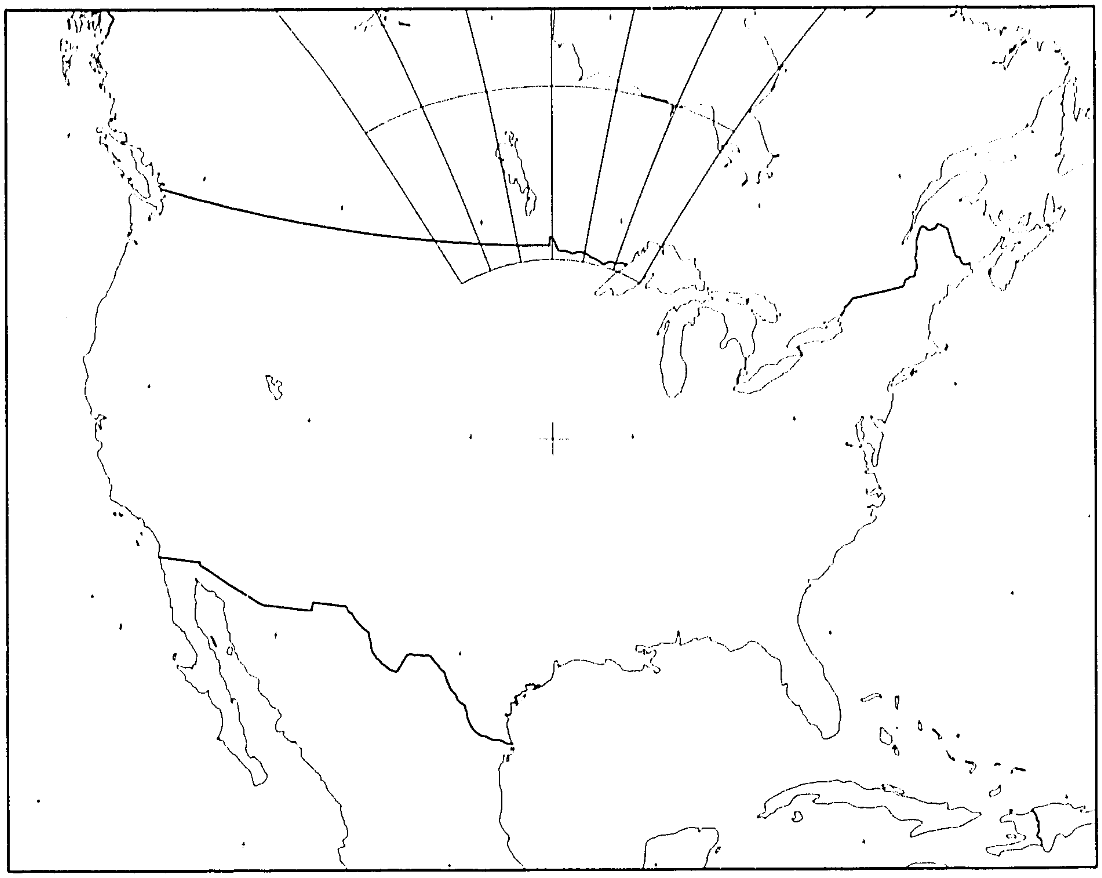

Figure 14. ALBERS

KAVRAISKIY IV

The Kavraiskiy IV with two standard parallels is the result of Russian efforts to develop a projection "with the least mean square linear distortion" for the area of the Soviet Union. Because it displays areas of large longitudinal extent so well, it is the choice for most maps and atlases of the Soviet Union. The sample shows the USSR with elevation rings and azimuths centered at 60°N., 40°E. Elevation rings are range rings vertically projected from a given center on the earth's surface and intersecting a plane at a given altitude.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
CEIKIV  0.,,,47.,,,62.
MAPSAL  60200000.
MAPBOUND  0.,,,88.,,,-20.,,,-140.
CETPOT  60.,,,100.
XYLIM  5.5,7.
SAVE
XYLIM  3.18,2.5
SAVE
2     11 x 14 ONE PLATE COMPOSITE
EOF
1     KAVRAISKIY IV
-3.18             -2.8
2     GRID, BOX AND COAST
LGRID 20.,20.,1.,1.,0.,,,90.,,,-20.,,,-140.
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
BOX  60.,,,100.,,,3.18,2.5
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2     BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2     AZIMUTHS AND ELEVATION RINGS
2     SCREEN 70
SPLATE
PLOTTER  14.,4.,.01,10.,1.,8.,,4.
SAVE
BODE  60.,,,040.,,,130.,1200.,20.,30.,100.,1500.,0.,80.,20.,1.,100.,90.,0 360.
SPLATE
```

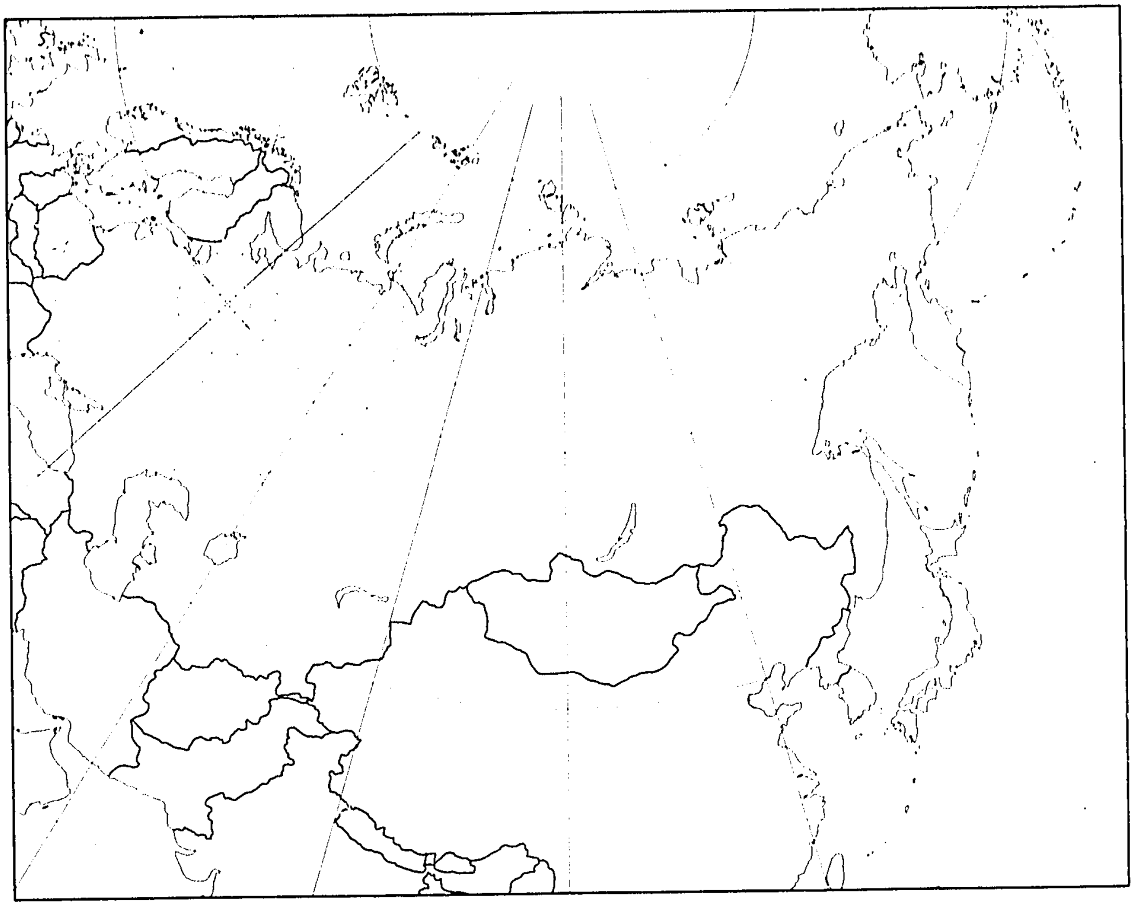

Figure 15. KAVRAISKIY IV

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LAMBERT CONFORMAL CONIC

The Lambert, with two standard parallels, differs from other conics only in the spacing of parallels. This spacing decreases between the standard parallels and increases beyond them so that the North-South scale at every latitude exactly matches the East-West scale. Its conformality gives it excellent azimuth and great-circle accuracies for midlatitude areas, particularly those with a large East-West extent. The Lambert is suitable for both large- and small-scale mapping and is the midlatitude projection used for most aeronautical charts. The facing map, centered on 60°N. and 150°E., illustrates a typical midlatitude application. The legend box and deletion of map detail within the box are new features of CAM.

```
PLOTTER  14.,7.,.01,10.,1.,8.,,4.
LAMBERT  0.,,,47.,,,62.
MAPSAL  60200000.
CETPOT  60.,,,150.
MAPBOUND  0.,,,88.,,,20.,,,-80.
XYLIM  5.5,7.
SAVE
2    LEGEND BOX
OPENBOX  1.,-3.08,-2.4,-.1,-9,1.
XYLIM  3.18,2.5
SAVE
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
2    11 x 14 ONE PLATE COMPOSITE
EOF
1    LAMBERT CONFORMAL CONIC
-3.18          -2.8
2    GRID, BOX AND COAST
LGRID  20.,20.,1.,1.,0.,,,88.,,,20.,,,-80.
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
BOX  60.,,,150.,,,3.18,2.5
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2    BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
SPLATE
```

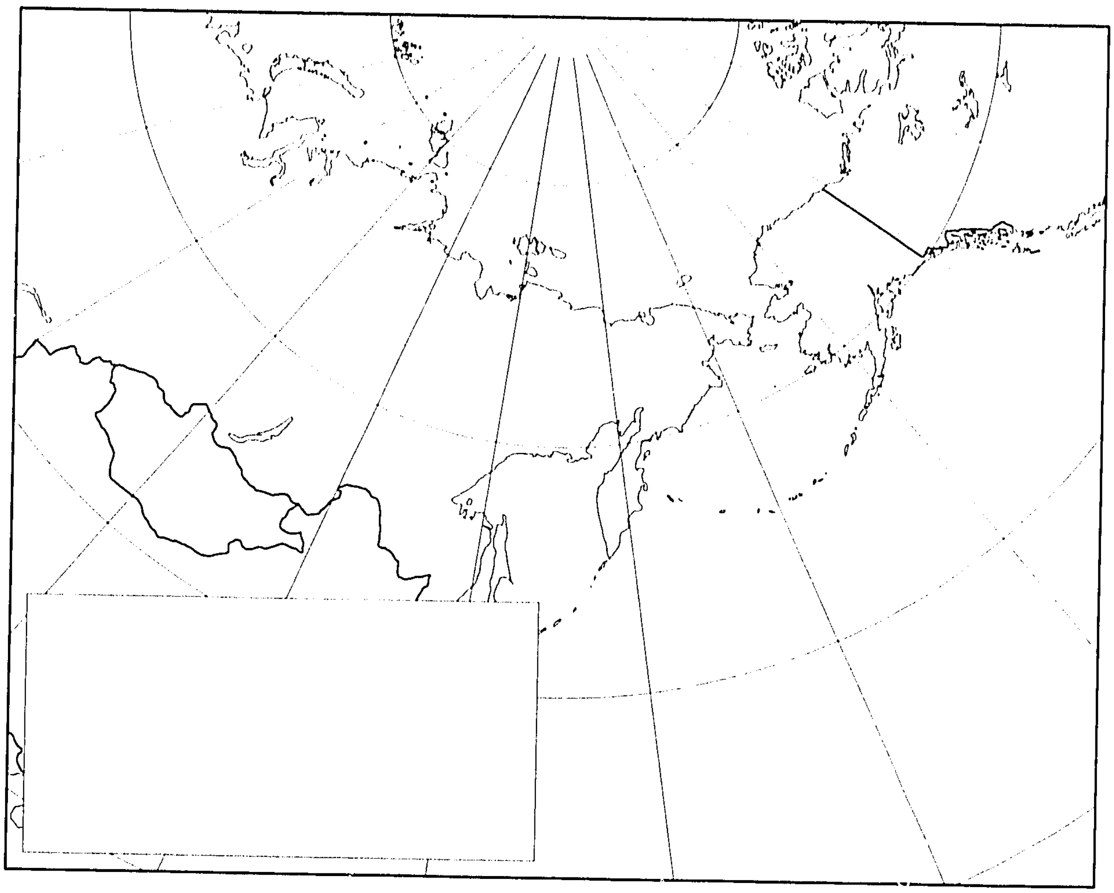

Figure 16. LAMBERT CONFORMAL CONIC

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PTOLEMY

This conic equal-interval projection, invented by Claudius Ptolemy in the 2nd century B.C., was rediscovered in the 15th century. It has a single standard parallel and equally spaced parallels and possesses the virtues of being easy to manually construct and plot on. The sample shows China with varying size circles centered on seven major cities.

```
PLOTTER  14.,2.,.01,10.,1.,,,4.
CEIPOS  0.,,,35.
MAPSAL  37000000.
CETPOT  36.,30.,,102.,30.
MAPBOUND  10.,,,60.,,,60.,,,150.
XYLIM  5.5,7.
SAVE
XYLIM  3.18,2.5
SAVE
2     11 X 14 1 PLATE
EOF
1     PTOLEMY     37 MILLION
-3.18              -2.8
LGRID  20.,20.,1.,1.,0.,,,60.,,,60.,,,150.
PLOTTER  14.,3.,.01,10.,1.,,,4.
LINEPT  1.,9.,1.
PLOTTER  14.,6.,.01,10.,1.,,,4.
LINEPT  12.,9.
PLOTTER  14.,8.,.01,10.,1.,,,4.
BOX  36.,30.,,102.,30.,,3.18,2.5
PLOTTER  14.,4.,.01,10.,1.,,,4.
SAVE
CIRCLE  39.,55.,,116.,19.,,1.5,2
CIRCLE  31.,15.,,121.,28.,,1.25,2.
CIRCLE  23.,06.,,113.,16.,,1.,2.
CIRCLE  45.,45.,,126.,41.,,.8,2.
CIRCLE  39.,08.,,117.,12.,,.6,2.
CIRCLE  29.,39.,,106.,34.,,.4,2.
CIRCLE  25.,05.,,102.,40.,,.2,2.
PLOTTER  14.,2.,.01,10.,2.,6.,,4.,,20.
SYMPT  2.,7.
  1+                                        395500N116190
  1+                                        311500N121280
  1+                                        230600N113160
  1+                                        454500N126410
  1+                                        390800N117120
  1+                                        293900N106340
  1+                                        250500N102400
                                            99
                                            99
SPLATE
```

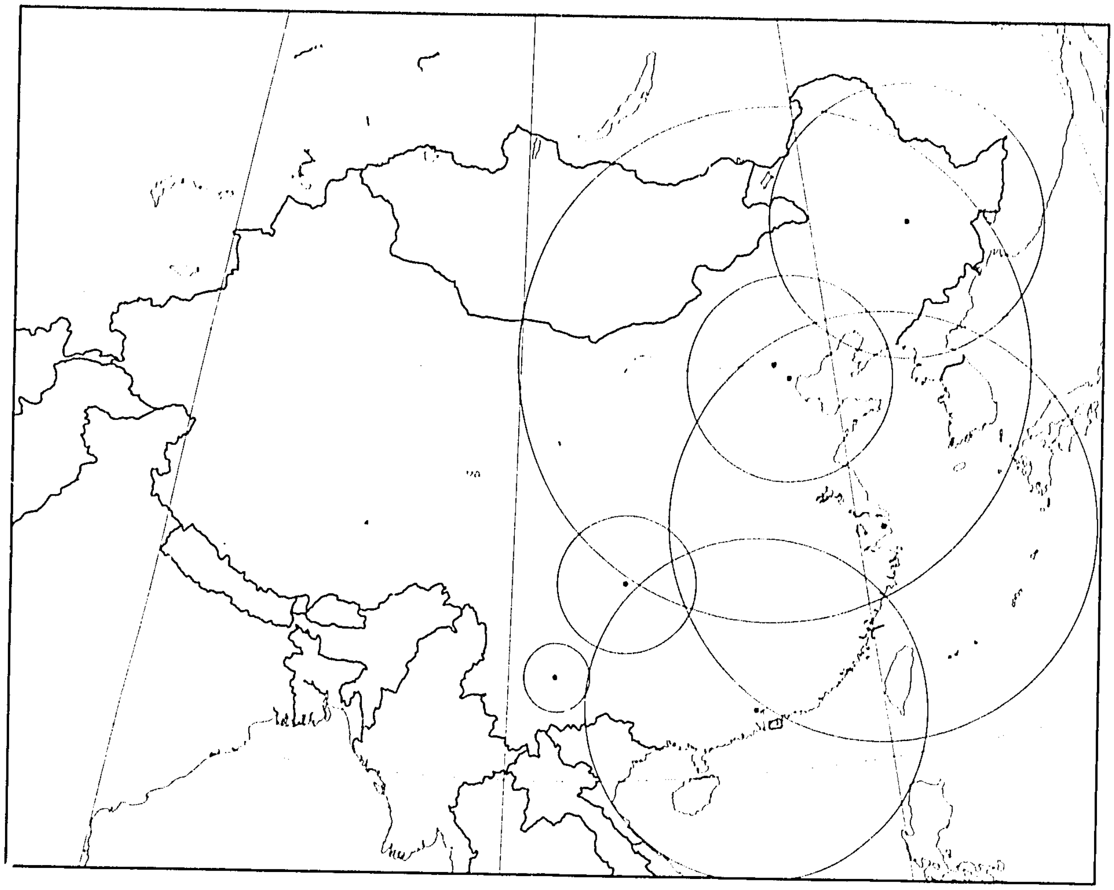

Figure 17. PTOLEMY

C. CYLINDRICAL PROJECTIONS

In theory, this class of projections is obtained by wrapping a cylinder around a sphere. Deformation increases away from the lines of tangency or intersection. In CAM there are two conformal projections, the Mercator and Transverse Mercator, and two compromise projections, the Equirectangular and the Miller. The UTM is not a projection but a grid system and is included here because of its wide usage.

EQUIRECTANGULAR

The Equirectangular Projection, often referred to as the plane chart, is produced by spacing the meridians and parallels at various ratios. It is most used for large-scale maps, such as city plans, although recent applications have included small-scale overlays on spatially ordered computer printout. In Figure 18, the meridians and parallels are equally spaced, one inch equalling ten degrees. Hand plotting over this type of map is very easy.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
RECTAN  3.,2.5
CETPOT  45.,,,-95.
MAPBOUND  20.,,,70.,,,-125.,,,-65.
XYLIM  5.5,7.
SAVE
XYLIM  4.25,5.5
SAVE
2      11 x 14 ONE PLATE COMPOSITE
EOF
1      EQUIRECTANGULAR
-3.             -2.75
2      GRID, BOX, AND COAST
LGRID  10.,10.,.25,.25,20.,,,70.,,,-125.,,,-65.
PLOTTER  14.,8.,.01,10.,1.,8.,,6.
SAVE
BOX  45.,,,-95.,,,3.,2.5
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2      BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2      CENTER AND CORNER TICKS
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CENTERTK
CORNERTK
SPLATE
```


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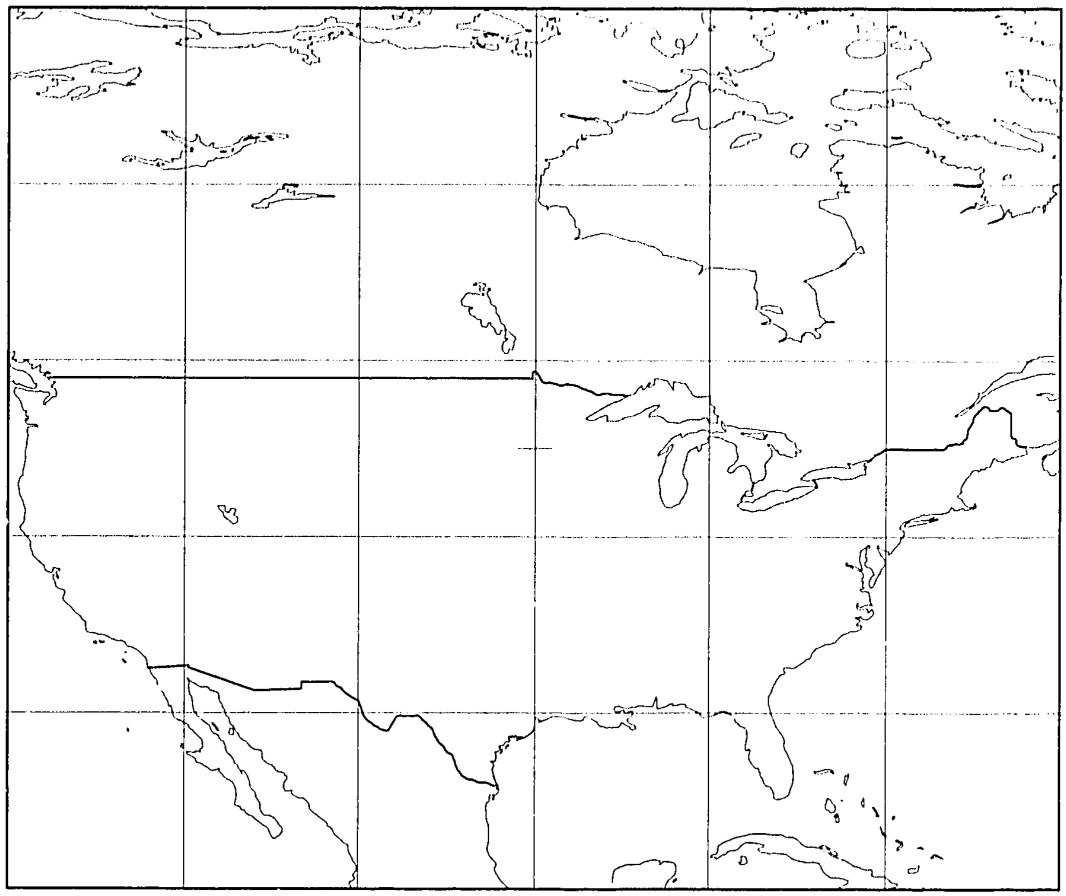

Figure 18. EQUIRECTANGULAR

MERCATOR

The spacing of parallels on the Mercator Projection increases progressively poleward from the equator in a way that makes the projection conformal, i.e., by increasing the North-South scale to exactly match the East-West scale at every latitude. This conformality means that any straight line on the Mercator Projection describes a compass course or rhumb line. Since its conception in 1569, this useful projection has been employed in many scales for navigation charts and equatorial areas. The user should be aware that distances and areas are seriously exaggerated at latitudes greater than 40°. Figure 19, centered on Washington, D.C., has a partial range ring and azimuth overplay plus a rhumb line between the center and Reykjavik, Iceland. Note the difference between the curved azimuth, which is the shortest distance between two points (great circle), and the straight rhumb line, which is a compass bearing that crosses successive meridians at a constant angle.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
MERCAT  0.
MAPBOUND  -15.,,,80.,,,,-180.,,,0.
CETPOT  38.,56.,,-77.,2.
MAPSAL  100000000.
XYLIM  5.5,7.
SAVE
XYLIM  3.18,2.5
SAVE
2    11 x 14 ONE PLATE COMPOSITE
EOF
1    MERCATOR
-3.18    -2.8
2    GRID, BOX AND COAST
LGRID  15.,15.,.25,.25,-15.,,,80.,,,-180.,,,0.
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
BOX  38.,56.,,-77.,2.,,3.18,2.5
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
SPLATE
2    BOUNDS
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
SPLATE
2    AZIMUTHS, RANGE RINGS AND RHUMB LINE
PLOTTER  14.,4.,.01,10.,1.,8.,,8.
SAVE
BODE  38.,56.,,-77.,2.,,500.,3000.,30.,1.,,,,,,,,,330.,30.
RRANGE  38.,56.,,-77.,2.,,330.,30.,1.,50.,3000.,500.
LINEPT  7.,5.
2222222                                       640900N0215100W
2222222                                       385600N0770302W
9
9
SPLATE
2    CENTER TICK
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
SAVE
CENTERTK
SPLATE
/*
```

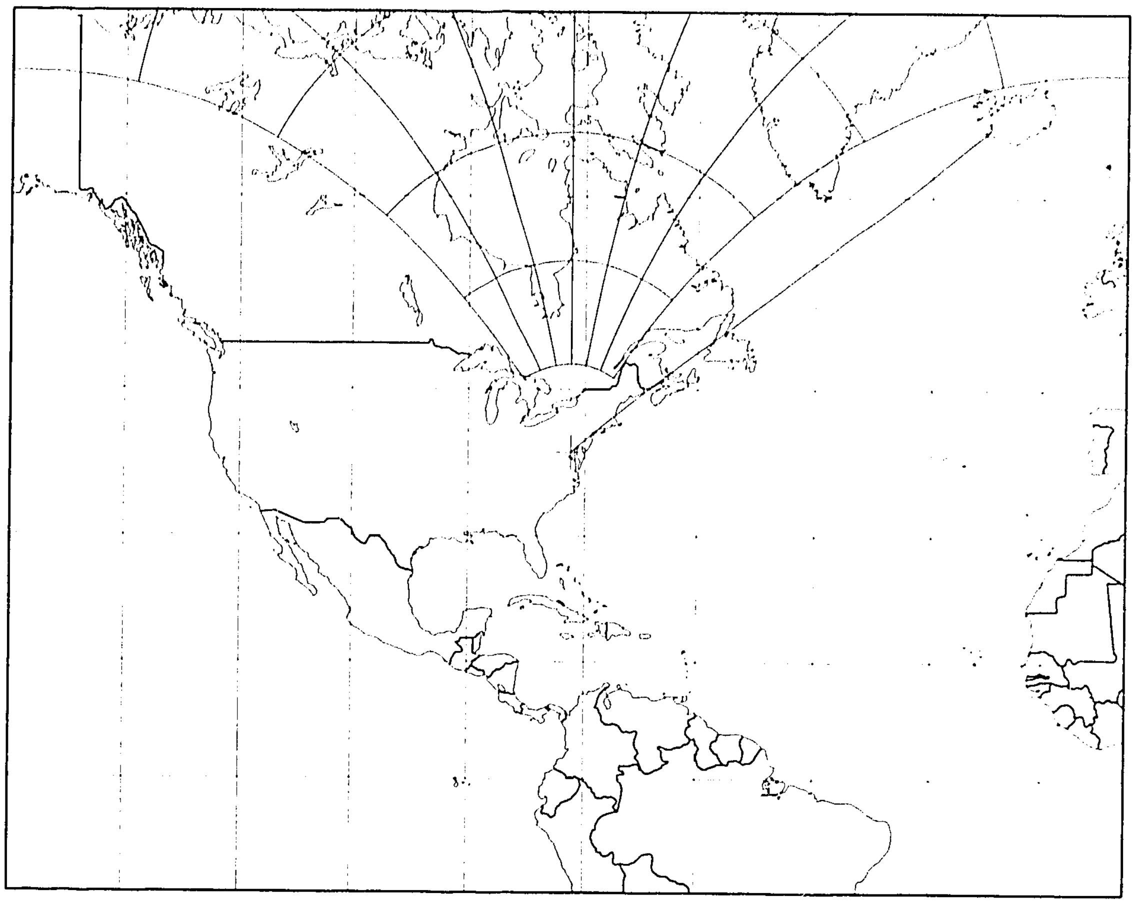

Figure 19. MERCATOR

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MILLER

Both the area compression of the Equirectangular Projection and the extreme scale expansion in the higher latitudes of the Mercator are objectionable features for general small-scale world maps. The most-used compromise between these two extremes is the Miller Projection, devised by O. M. Miller of the American Geographical Society during World War II. This projection is neither conformal nor equal-area and generally is limited to small-scale maps. Figure 20, an atlas base map for showing world distributions, is a typical application.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
MILCYL  0.
MAPBOUND  -80.,,,80.,,,-179.,59.,59.,180.
CETPOT  0.,,,0.
MAPSAL  254500000.
XYLIM  5.5,7.
SAVE
XYLIM  3.1,1.8
SAVE
2     11 x 14 ONE PLATE COMPOSITE
EOF
1     MILLER CYLINDRICAL
-3.1            -2.1
2     GRID
LGRID  30.,30.,.25,.25,-90.,,,90.,,,-179.,59.,59.,180.
SPLATE
2     BOX
PLOTTER  14.,8.,.01,10.,1.,8.,,4.
SAVE
BOX  0.,,,0.,,,3.1,1.8
2     COAST
PLOTTER  14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT  8.,2.
2     BOUND
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT  11.,2.
2     AZIMUTHS AND RANGE RINGS
PLOTTER  14.,4.,.01,10.,1.,8.,,4.
SAVE
RRANGE  0.,,,0.,,,330.,30.,1.,2580.,9000.,1000.
BODE  0.,,,0.,,,2580.,8580.,30.,10.,,,,,,,,330.,30.
SPLATE
```

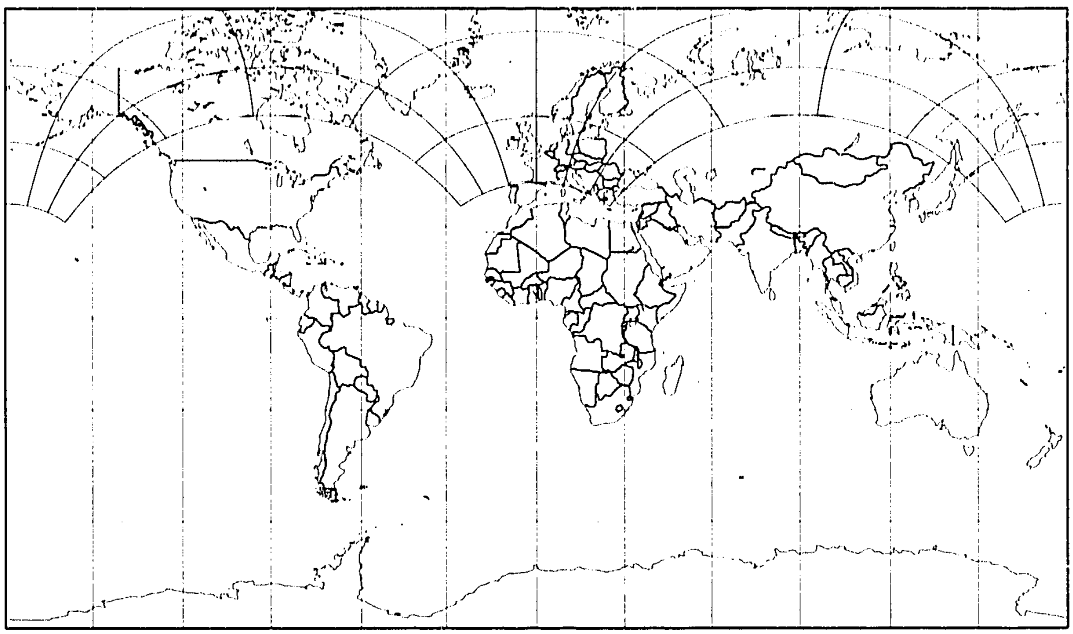


Figure 20. MILLER

TRANSVERSE MERCATOR

This projection, an adaption of the Mercator, uses a meridian rather than the Equator for the line of true scale. All of the conformal relationships of the Mercator, except the rhumb line property, are retained in the Transverse Mercator. It is a superior projection for a 15 to 20 degree band centered on its central meridian but, except for its adaption in the Universal Transverse Mercator grid system, it has rarely been used.

The coordinates of the center point of the central meridian in this version of CAM are 0°N. and 0°E. By including the equations found on pages 6 and 7 of *Conformal Projections in Geodesy and Cartography* by Paul D. Thomas, the Transverse Mercator Projection can be converted into an Oblique Mercator Projection centered on any great circle other than the Equator or a meridian. In the past, such maps were employed for air navigation. The figure opposite employs the Transverse Mercator Projection to illustrate the relationship of North America to Asia via the South Pole.

```
PLOTTER  14.,2.,.01,10.,1.,7.,,4.
TMERCT  0.
CETPOT  0.,,,-90.
MAPSAL  240000000.
MAPBOUND  -89.0,,89.8,,,-180.,,,0.
XYLIM  5.5,7.
SAVE
2     PLOT ON 11 BY 14
2     2 PLATES
XYLIM  .95,1.65
SAVE
PLOTTER  14.,6.,.01,10.,1.,8.,,4.
SAVE
BOX  0.,,,-90.,,,.95,1.65
PLOTTER  14.,2.,.01,10.,1.,7.,,4.
SAVE
LGRID  15.,15.,2.,2.,-89.8,,89.0,,,-180.,,,0.
LINEPT  8.,2.
SPLATE
CETPOT  0.,,,90.
MAPBOUND  -89.0,,89.8,,0.,,,180.
SAVE
PLOTTER  14.,6.,.01,10.,1.,7.,,4.
SAVE
BOX  0.,,,90.,,,.95,1.65
PLOTTER  14.,2.,.01,10.,1.,7.,,4.
SAVE
LGRID  15.,15.,2.,2.,-89.8,,89.0,,0.,,,180.
LINEPT  8.,2.
SPLATE
```

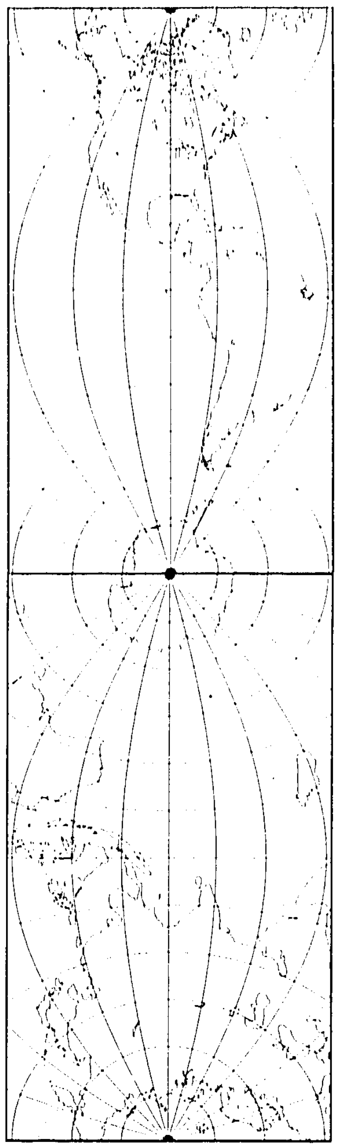


Figure 21. TRANSVERSE MERCATOR

UNIVERSAL TRANSVERSE MERCATOR (UTM)

The Universal Transverse Mercator, commonly referred to as "UTM," is not a projection but a sophisticated grid system based on the Transverse Mercator Projection. Central meridians are constructed every 6° of longitude running from 80°N. to 80°S. Zones, extending 3° to either side of the central meridian, are overlaid by a uniform rectangular (military) grid. These grids are used in large-scale precision mapping and can be overlaid on projections other than the Transverse Mercator. Figure 22 is a section of an UTM grid plotted over a Transverse Mercator urban plan. Figure 23 has been included as a reference aid to determine the correct spheroid for different areas of the world.

```
PLOTTER  14.,1.,.01,10.,1.,,,4.
TMERSD  6378388.,6356912.,39.
MAPSAL  35000.
CETPOT  55.,43.,,37.,33.
MAPBOUND  55.,41.,,55.,45.,,37.,30.,,37.,36.
XYLIM  9.,10.
SAVE
2      18 x 20  DRUM
EOF
UTMGRID  1000.,1000.,20.,20.,55.,41.,,55.,45.,,37.,30.,,37.,36.,,37.,1.
CORNERTK
SPLATE
```

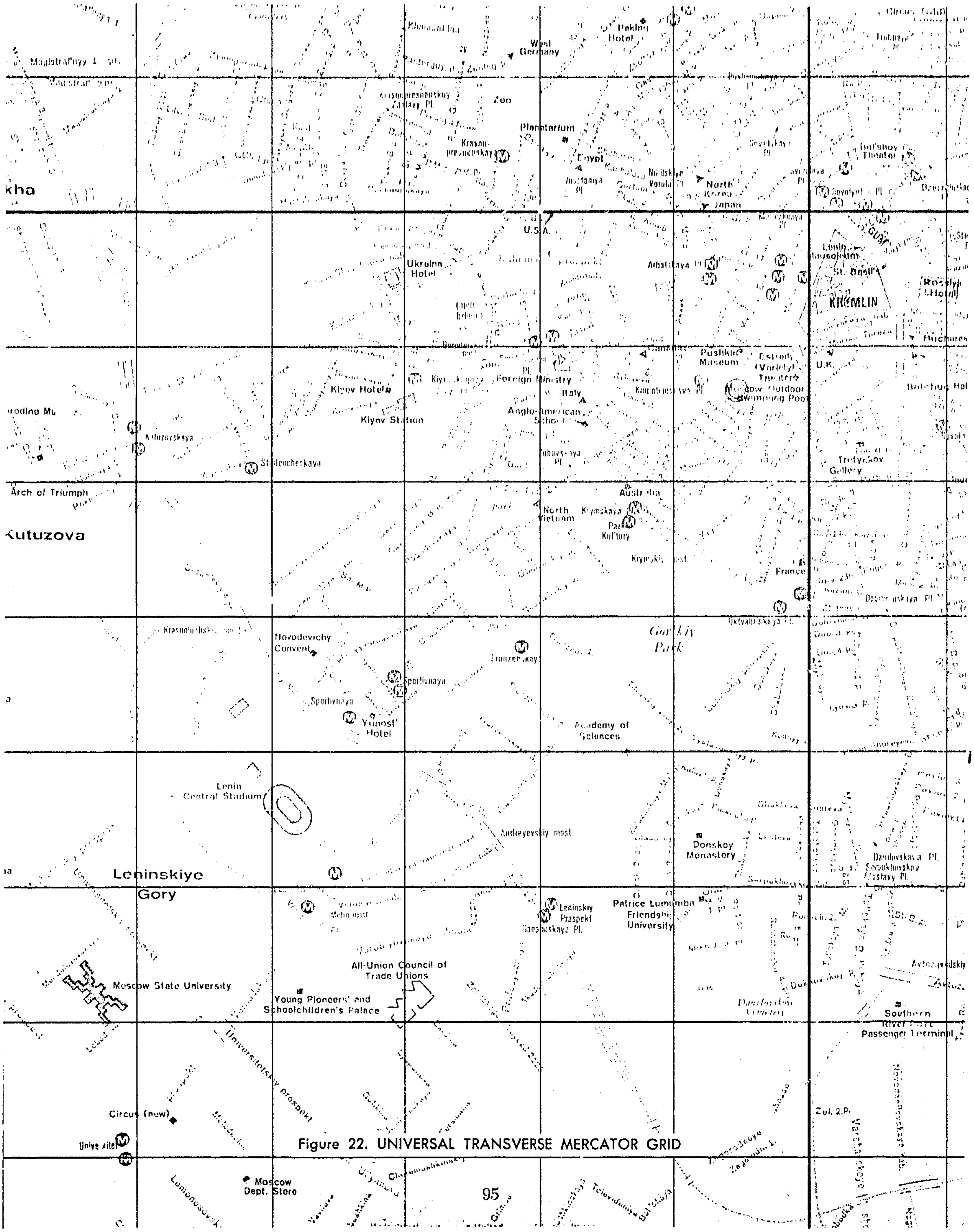


Figure 22. UNIVERSAL TRANSVERSE MERCATOR GRID

The UTM system uses 60 zones, each zone is six degrees wide in longitude. The central meridians of the zones are the following:

3°, 9°, 15°, 21°, 27°, 33°, 39°, 45°, 51°, 57°, 63°, 69°, 75°, 81°, 87°, 93°, 99°, 105°, 111°, 117°, 123°, 129°, 135°, 141°, 147°, 153°, 159°, 165°, 171°, and 177° East and West.

If the grid zone number is known, the central meridian of that zone is equal to grid zone number times 6 minus 183. The false Easting for each zone is 500,000 meters at the central meridian. The false Northing is zero meters for the Northern Hemisphere and 10,000,000 meters for the Southern Hemisphere. The scale factor on the central meridian is 0.9996. The semi-major and semi-minor axis lengths in meters for the spheroids are the following:

	Semi-major Axis	Semi-minor Axis
Bessel	6,377,397.155	6,356,079
Clarke 1866	6,378,206.4	6,356,583.8
Clarke 1880	6,378,249.145	"
Everest	6,377,276.345	6,356,075
International	6,378,388	6,356,912

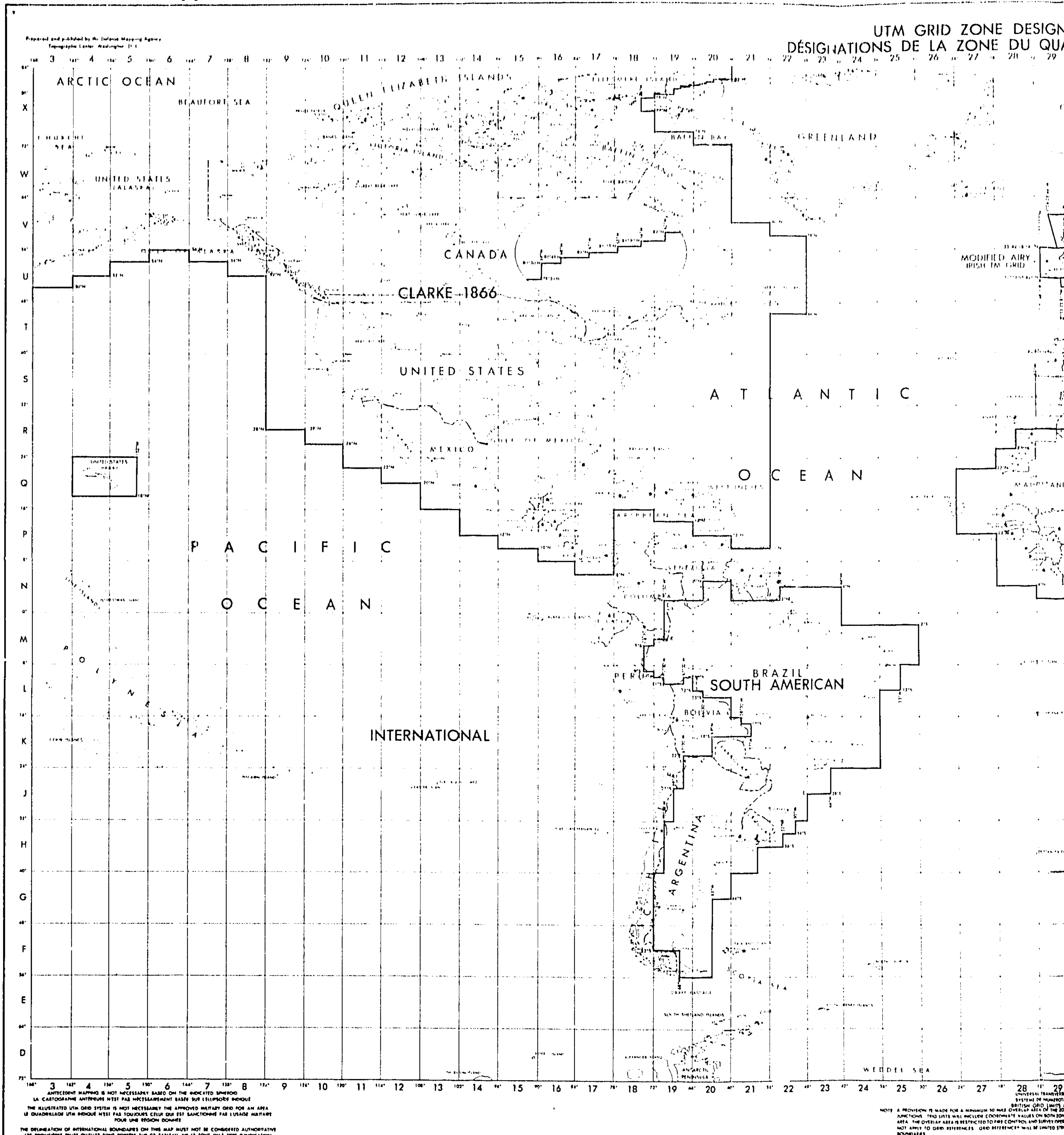


Figure 23. UTM Gr

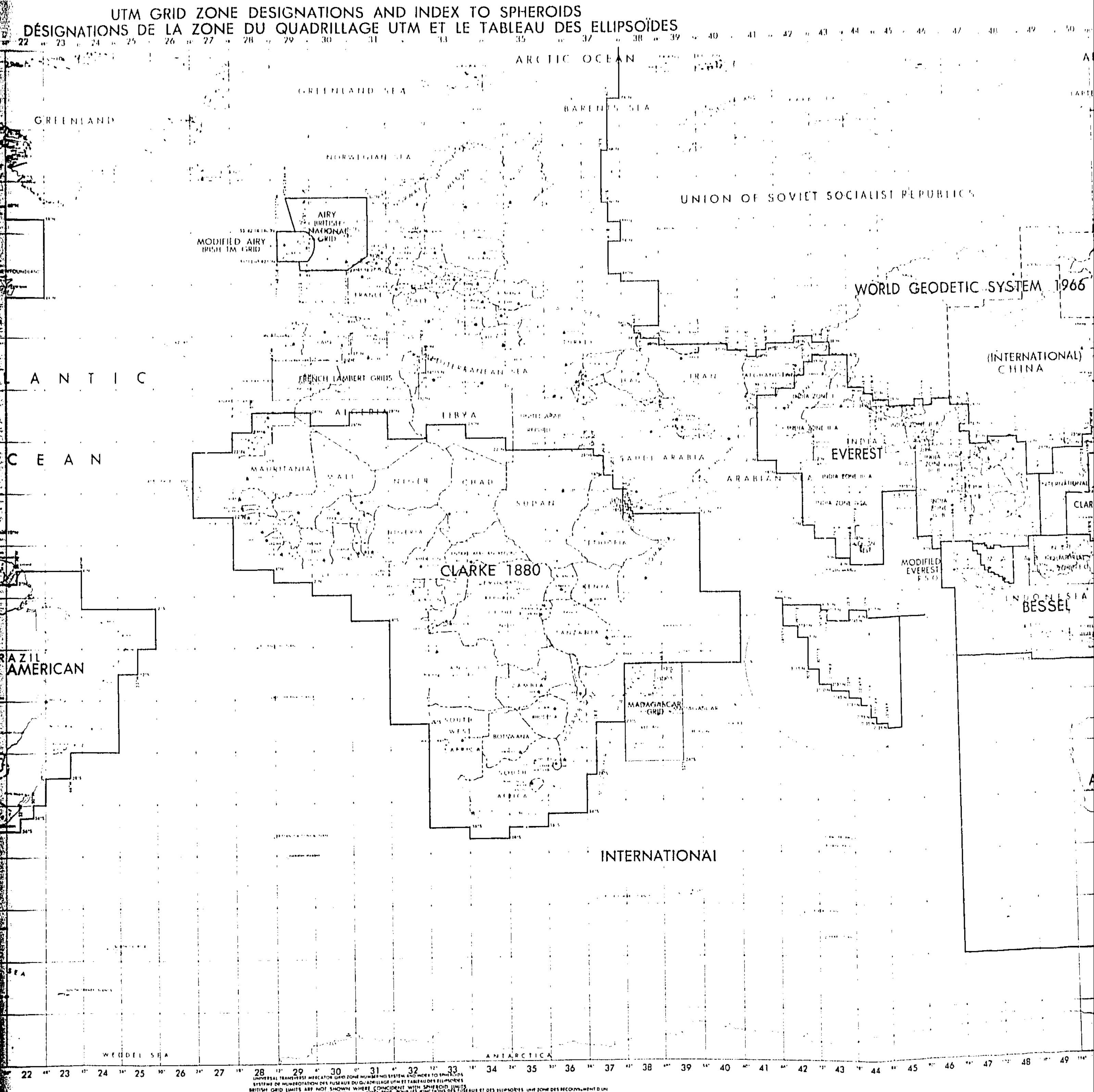
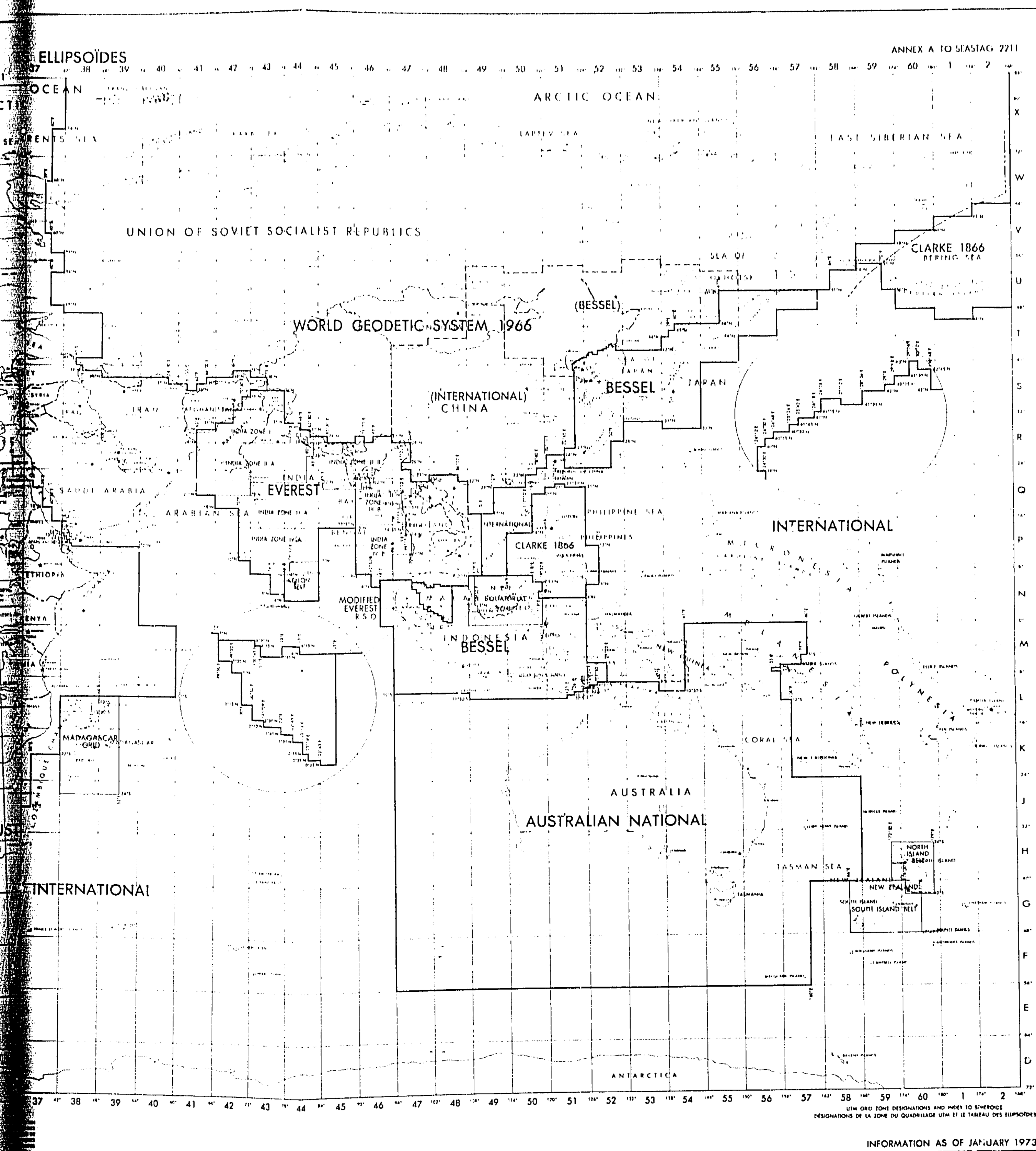


Figure 23. UTM GRID ZONE DESIGNATIONS AND INDEX TO SPHEROIDS



SPHEROIDS

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D. MISCELLANEOUS

The following two projections and display routine do not fall in any of the above constructional groupings. The Sinusoidal is an equal-area projection for small-scale maps, while the Polyconic is a compromise projection employed at larger scales. The XY Display does not employ latitude-longitude data and is, therefore, not a projection.

POLYCONIC

Each of the parallels in the Polyconic Projection is a standard parallel, resulting in a projection that is neither equivalent nor conformal. However, both properties are approximated when the mapped area is small and bisected by the central meridian. The U.S. Geological Survey employs the Polyconic for the standard topographic map series. Figure 24 is an example of a USGS 7.5 Minute Series Quadrangle overlain by a UTM grid. Only a portion of the map is shown.

```
PLOTTER  14.,2.,.01,10.,1.,,,4.
POLYCON  6378206.4,6356583.8,-75.
CONFAC  39.37
MAPSAL  24000.
CETPOT  38,41,15,-77,11,15
MAPBOUND  38,37,30,38,45,,-77,15,,-77,07,30
XYLIM  12,15
SAVE
XYLIM  9.5,12.
SAVE
2    24 x 30 ONE PLATE
EOF
1    UTM 500 METERS
-8.  -12.
UTMGRID  500,500,500,500,58,37,30,38,45,,-77,15,,-77,07,30,18,4
CORNERTK
SPLATE
```

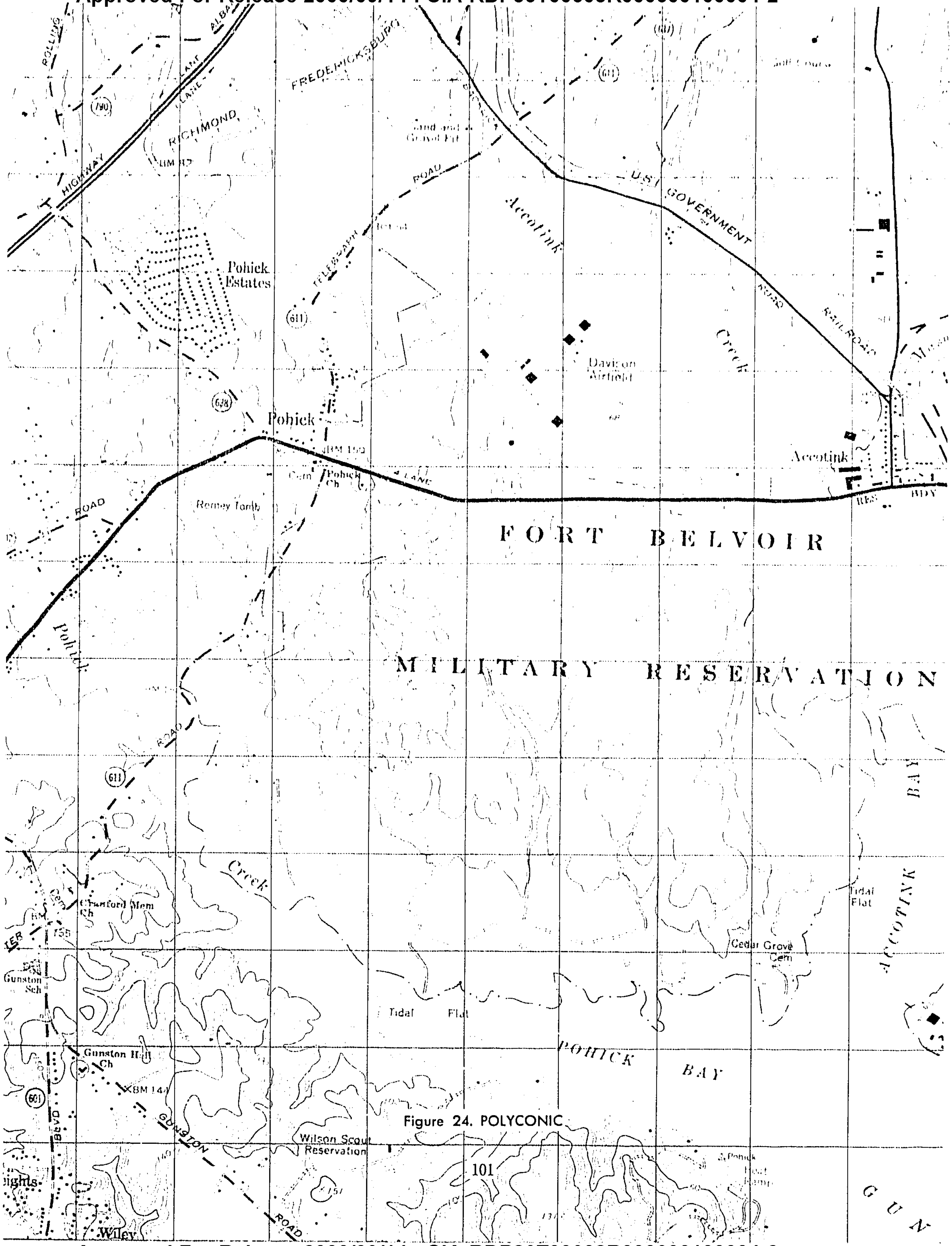

Figure 24. POLYCONIC

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SINUSOIDAL

The Sinusoidal or Mercator Equal-Area Projection was created to reduce the distortions of shape present in a Cylindrical Equal-Area Projection. It is an excellent choice for maps with significant North-South dimensions, such as hemispheres and continents and especially South America and Africa. The equally spaced parallels and true meridional divisions are also convenient for manual plotting of data.

Figure 25 in addition to being an example of the Sinusoidal Projection also illustrates a new CAM feature, the corridor, which can be drawn parallel to either or both sides of a given line. In this case, a 200 nautical mile corridor has been plotted connecting the three cities shown on map.

```
PLOTTER   14.,2.,.01,10.,1.,8.,,4.
SINEAR
CETPOT   0.,,,-90.
MAPBOUND   -90.,,,90.,,,-170.,,,-10.
MAPSAL   125000000.
XYLIM   5.5,7.
SAVE
XYLIM   4.25,5.5
SAVE
2     11 x 14   ONE PLATE COMPOSITE
EOF
1     SINUSOIDAL
-3.18              -4.
2     GRID
LGRID   10.,10.,.25,.25,-90.,,,90.,,,-170.,,,-10.
2     COAST
PLOTTER   14.,3.,.01,10.,1.,8.,,4.
SAVE
LINEPT   8.,2.
2     BOUNDS
PLOTTER   14.,6.,.01,10.,1.,8.,,4.
SAVE
LINEPT   11.,2.
2     CITIES, LINE PLOTS AND CORRIDOR
PLOTTER   14.,12.,.01,10.,2.,0.,,4.,,19.
SAVE
SYMPT   2.,7.
  1+                                              103000N0665800W
  1+                                              163100S0680300W
  1+                                              384500S0620700W
                                                  99
2     SCREEN   70                                 99
EOF
PLOTTER   14.,4.,.01,10.,1.,8.,,4.
SAVE
CORRIDOR   7.,5.,5.,2.,100.,0.,20.
1000010                                           103000N0665800W
1000010                                           163100S0680300W
1000010                                           384500S0620700W
9
9
2     CENTER AND CORNER TICKS REMOVE SCREEN
SPLATE
PLOTTER   14.,2.,.01,10.,1.,8.,,4.
SAVE
CORNERTK
CENTERTK
SPLATE
```

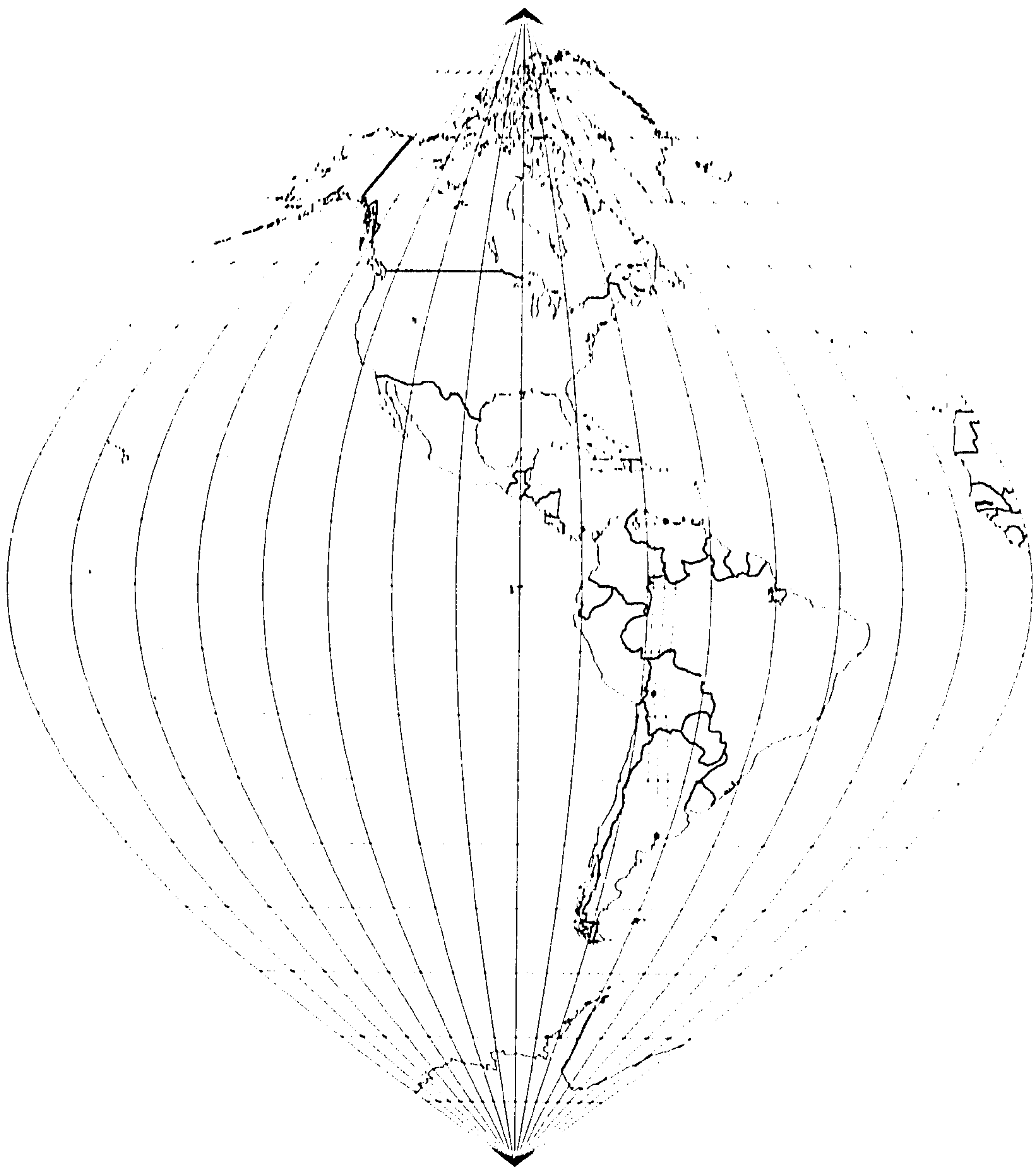

Figure 25. SINUSOIDAL

XY DISPLAY

This is not a projection but a routine to display XY data derived from the digitizer, interactive cathode ray tube or manual means. It is most frequently used to proof digitized data. In previous versions of CAM, this was called "One for One."

Figure 25 is an example of the XY Display. Its purpose was to demonstrate the capabilities of the SOLIDFIL routine which fills areas with line or symbol patterns or solidly. It was derived by using a cartesian coordinate (XY) system and the Graphic Data Format.

```
PLOTTER   14,1,0.01,8,1,10,0,11,0
ONOPOT   1,1
CETPOT   40,,,100
MAPBOUND   30,,,50,,,80,,,120
MAPSAL   1
XYLIM   6.1,6.1
XYOFF   -5.1,-5.1
CORNERTK
SAVE
LINEPT   7,3
B
[to draw outline of areas]
L00000010100
      0  5500
   3500  5500
   3500   200
      0   200
      0 10000
  10000 10000
  10000  7500
   8000  7600
   7000  7000
   4000  7500
   2000  8000
   1000 10000
L00000020100
  10000  7500
  10000     0
   3700     0
   3700  2600
   6000  2600
   6000  4000
  10000  4000
L00000030101
  10000  6500
   3000  6500
   3000  5500
L00000040101
   3500  4000
   6000  4000
L00000050101
   6000  2600
   6000     0
L00000060101
```

```
   8000      0
   8000   4000
L00000070101
   3800   3000
   4200   3000
   4200   3500
   3800   3500
   3800   3400
   3750   3400
   3750   3100
   3800   3100
   3800   3000
L00000080101
   5000   3100
   5700   3100
   5700   3500
   5000   3500
   5600   3800
   5000   3800
   5000   3100
L00000090101
   5100   3250
   5100   3450
   5600   3450
   5600   3250
   5100   3250
L00000310101
   1100   3500
   1000   3800
   1500   4100
   1700   4100
   1700   3900
   1400   3400
   1100   3500
E
PLOTTER   14,02,0.01,8,3,20,0,11,0,99
SOLIDFIL  7,3,0.3,2,0.  [to fill with symbol "t"]
B
L00000100101
   1000  10000
   2000   8000
   4000   7500
   7000   7000
   8000   7600
  10000   7500
  10000  10000
E
PLOTTER   14,03,0.01,8,3,14,45,11,0,86
SOLIDFIL  7,3,0.25,2,45.  [to fill with symbol "o"]
B
L00000200101
      0  10000
      0   5500
   3000   5500
   3000   6500
  10000   6500
  10000   7500
   8000   7600
   7000   7000
   4000   7500
   2000   8000
   1000  10000
```

```
E
PLOTTER   14,1,0.01,8,0,20,0,11,0
SOLIDFIL  7,3,0.2,3,30.   [to cross hatch at 30° open area near middle]
B
L00000300101
      0  5500
      0   200
   3500   200
   3500  5500
L00000310101
   1100  3500
   1000  3800
   1500  4100
   1700  4100
   1700  3900
   1400  3400
E
PLOTTER   14,2,0.01,8,0,20,0,11,0
SOLIDFIL  7,3,0.15,1,45.  [line fill at 45°]
B
L00000400101
   3500  4000
  10000  4000
  10000  6500
  30000  6500
  30000  5500
   3500  5500
E
PLOTTER   14,1,0.01,8,0,20,0,11,0
SOLIDFIL  7,3,0.1,1,0.      [line fill at 0°]
B
L00000500101
   8000     0
  10000     0
  10000  4000
   8000  4000
E
PLOTTER   14,2,0.01,8,0,20,0,11,0
SOLIDFIL  7,3,0.1,3,60.    [cross latch at 60°]
B
L00000600101
   6000     0
   8000     0
   8000  4000
   6000  4000
E
PLOTTER   14,01,0.01,8,3,10,145.,11,0,98
SOLIDFIL  7,3,0.2,2,-45.  [fill with symbol "s" at −45°]
B
L00000700101
   3700     0
   6000     0
   6000  2600
   3700  2600
E
PLOTTER   14,2,0.01,8,0,14,0,11,0
SOLIDFIL  7,3,0.01,1,0     [solid fill house with 0.01" weight line]
B
L00000800101
   3800  3000
   4200  3000
   4200  3500
   3800  3500
```

```
   3800   3400
   3750   3400
   3750   3100
   3800   3100
E
PLOTTER   14,3,0.01,8,0,14,0,11,0
SOLIDFIL   7,3,0.02,1,0       [Solid fill barn with 0.02" weight line]
E
L00000000101
   5000   3100
   5700   3100
   5700   3500
   5600   3500
   5600   3800
   5000   3800
L00000910101
   5100   3250
   5100   3450
   5600   3450
   5600   3250
E
SPLATE
```

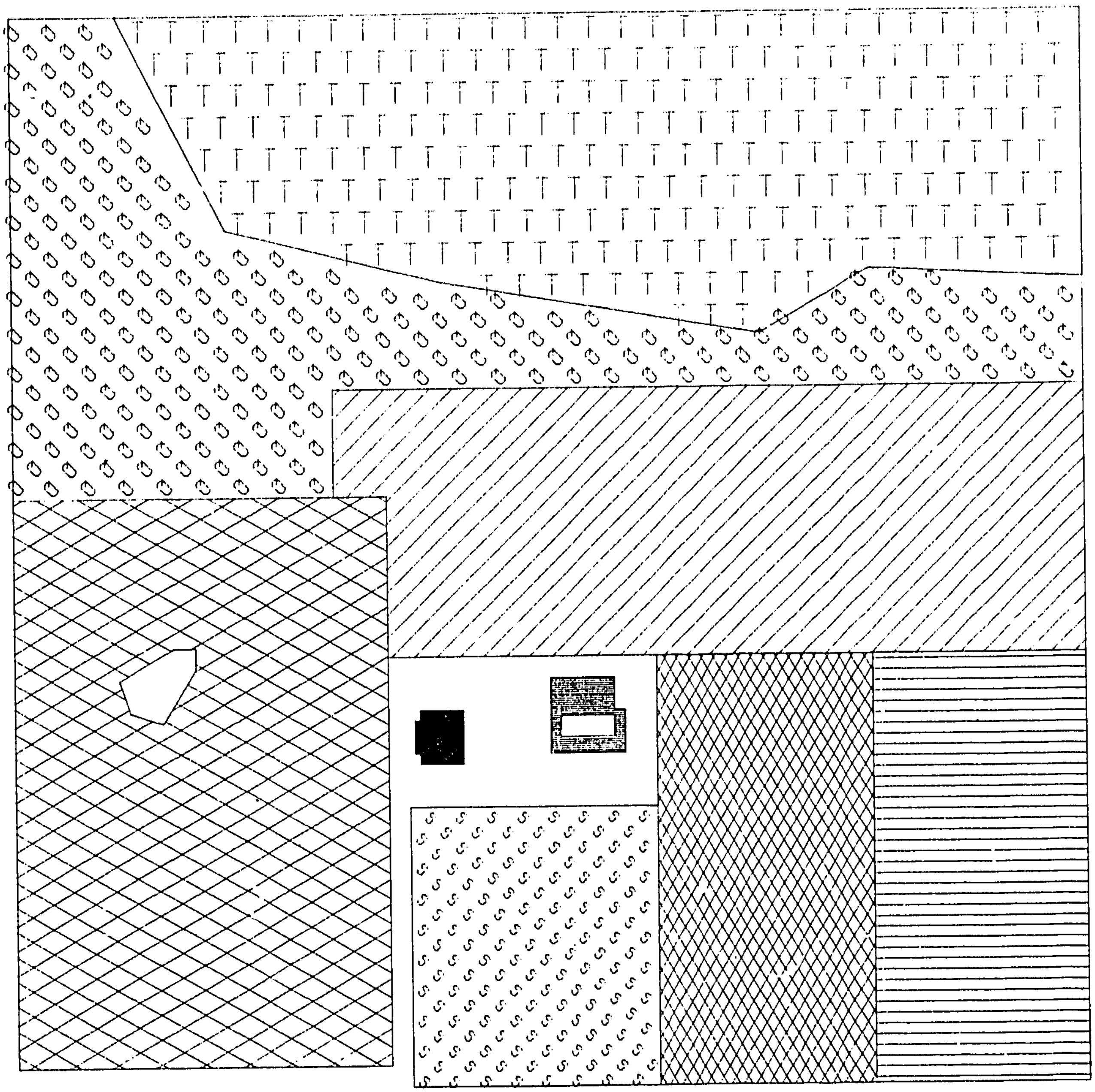

Figure 26. XY DISPLAY

E. SYMBOLS

A new feature in this version of CAM is a selection of symbols found in the LINEMODE option described in Chapter I, Section E. Included are solid and various dashed lines, canal and reef symbols, and a selection of railroad representations.

```
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
RECTAN  5.,6.
CETPOT  0.,,,0.
MAPBOUND  -50.,,,50.,,,-50.,,,50.
XYLIM  5.5,7.
SAVE
XYLIM  5.,6.
SAVE
EOF
PLOTTER  14.,5.,.01,10.,1.,8.,,4.
SAVE
SYMPT  2.,7.
25  SOLID LINE                                          400000N0400000W
25  DASHED LINE                                         360000N0400000W
25    REGULAR                                           320000N0400000W
25    LONG - SHORT - LONG                               300000N0400000W
35    LONG - SHORT - SHORT - LONG                       280000N0400000W
39    LONG - SHORT - SHORT - SHORT - LONG               260000N0400000W
25  RAILROADS                                           220000N0400000W
35    STANDARD AND BROAD GAUGE                          180000N0400000W
35    STANDARD AND BROAD GAUGE                          160000N0400000W
30      UNDER CONSTRUCTION                              150000N0400000W
30    NARROW GAUGE                                      130000N0400000W
30    NARROW GAUGE                                      110000N0400000W
30      UNDER CONSTRUCTION                              100000N0400000W
20  CANAL                                                60000N0400000W
20  REEF                                                 20000N0400000W
                                                        99
                                                        99
SPLATE
PLOTTER  14.,10.,.01,10.,1.,8.,,4.
SAVE
LINEPT  7.,5.
1000010                                     400000N0050000W
1000010                                     400000N0080000E
9
PLOTTER  14.,7.,.01,10.,1.,8.,,4.
LINEMODE  1.,.1,.02
SAVE
LINEPT  7.,5.
1000020                                     320000N0050000W
1000020                                     320000N0080000E
9
9
PLOTTER  14.,7.,.01,10.,1.,8.,,4.
LINEMODE  2.,.15,.045,.015
SAVE
LINEPT  7.,5.
1000030                                     300000N0050000W
1000030                                     300000N0080000E
9
9
PLOTTER  14.,7.,.01,10.,1.,8.,,4.
LINEMODE  3.,.15,.045,.015
SAVE
LINEPT  7.,5.
1000040                                     280000N0050000W
```

```
1000040                              280000N0080000E
9
9
PLOTTER  14.,7.,.01,10.,1.,8.,,4.
LINEMODE  12.,.15,.045,.015
SAVE
LINEPT  7.,5.
1000050                              260000N0050000W
1000050                              260000N0080000E
9
9
PLOTTER  14.,5.,.01,10.,1.,8.,,4.
LINEMODE  4.,.2,.05,2.,5.
SAVE
LINEPT  7.,5.
1000060                              180000N0050000W
1000060                              180000N0080000E
9
9
PLOTTER  14.,5.,.01,10.,1.,8.,,4.
LINEMODE  6.,.2,.025,2.,.05,5.
SAVE
LINEPT  7.,5.
1000070                              160000N0050000W
1000070                              160000N0080000E
9
9
PLOTTER  14.,5.,.01,10.,1.,8.,,4.
LINEMODE  5.,.2,.025,2.,.05,5.
SAVE
LINEPT  7.,5.
1000080                              130000N0050000W
1000080                              130000N0080000E
9
9
PLOTTER  14.,5.,.01,10.,1.,8.,,4.
LINEMODE  7.,.2,.025,2.,.025,5.
SAVE
LINEPT  7.,5.
1000090                              110000N0050000W
1000090                              110000N0080000E
9
9
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
LINEMODE  11.,.15,.03,2.,5.
SAVE
LINEPT  7.,5.
1000120                              60000N0050000W
1000120                              60000N0080000E
9
9
PLOTTER  14.,2.,.01,10.,1.,8.,,4.
LINEMODE  8.,.02
SAVE
LINEPT  7.,5.
1000130                              20000N0050000W
1000130                              20000N0080000E
9
9
SPLATE
/*
```

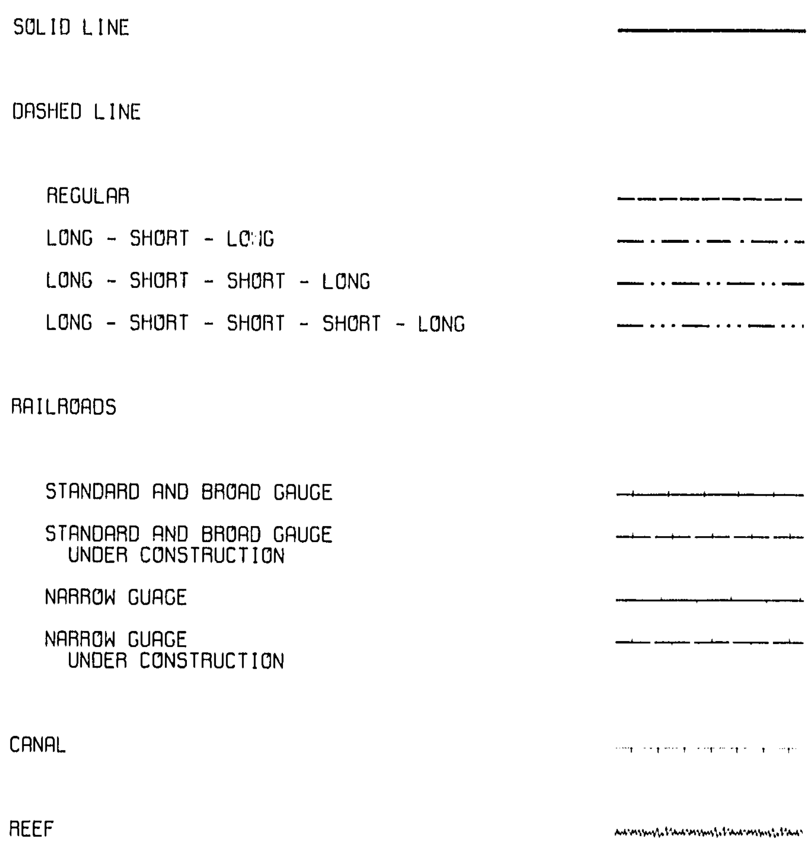

Figure 27. SYMBOLS

Approved For Release 2000/09/14 : CIA-RDP86T00608R000600100004-2